An atlas of the January distribution of selected marine fish species in the Cabot Strait from 1994 to 1997

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ABSTRACT

The geographic distribution of 25 marine fish species was examined using data collected during bottom trawl surveys conducted each January from 1994 to 1997. Over 90 species / species groups were captured during the four years of surveys. The geographic distribution of the 25 marine fish species that comprised 98% of the catches by weight is described. An analysis of diel differences in catchability was first conducted and correction factors were applied for 4 species. Standardized catches (in numbers and weights) were contoured using Delaunay triangulation. For seven commercial species, the distribution is described for fish smaller and larger than the minimum regulated size or size at maturity. High concentrations of commercial species were found throughout the area surveyed except in the shallowest areas. The results suggest that the Cabot Strait is an important over-wintering area for many fish populations, some of which are found in the Gulf of St. Lawrence during the summer.

RÉSUMÉ

La répartition géographique de 25 espèces de poissons a été étudiée à partir des données recueillies au cours de relevés au chalut de fond réalisés en janvier, de 1994 à 1997. Durant les quatre années du relevé, plus de 90 espèces ou groupes d'espèces ont été capturés. La répartition géographique des 25 espèces de poisson examinées, représentant 98 % des prises selon le poids, est décrite. Une analyse de la différence de capturabilité entre le jour et la nuit a été effectuée et des facteurs de correction ont été utilisés pour 4 espèces. Les prises standardisées (en poids et en nombre) ont été cartographiées par triangulation de Delaunay. Dans le cas de sept espèces commerciales, on a étudié la répartition des poissons dont la taille était inférieure et supérieure à la taille réglementaire minimale ou à la taille à la maturité. Des concentrations élevées d'espèces ayant une valeur commerciale ont été retrouvées dans toute la zone du relevé sauf dans les régions moins profondes. Les résultats semblent indiquer que le Détroit de Cabot est une importante aire d'hivernage pour bon nombre de poissons dont plusieurs sont des populations de poissons qui se retrouvent dans le Golfe du St. Laurent durant été.

INTRODUCTION

Several marine fish species from the Gulf of St. Lawrence are known to overwinter in the Cabot Strait (Figure 1). It has been known for a long time that cod (*Gadus morhua*) stocks from both the northern and southern Gulf are found in this area in winter (Halliday and Pinhorn 1982). The same appears to be true for herring (*Clupea harengus*), redfish (*Sebastes* sp.) and white hake (*Urophycis tenuis*). There is also evidence that other commercial species such as American plaice (*Hippoglossoides platessoides*) and witch flounder (*Glyptocephalus cynoglossus*) migrate from the shallower waters of the southern Gulf to the deeper waters of the Laurentian Channel, but the extent of their migrations is less well known. Thus, the waters of the Cabot Strait appear to be an important over-wintering area for many commercial species from the Gulf of St. Lawrence. It is likely that this area is also an important over-wintering area for non-commercial marine fish species of which some may spend the summer in the Gulf of St. Lawrence.

During the mid-1990's, a series of bottom-trawl surveys were conducted in the Cabot Strait during the month of January. The primary purpose of the surveys was to gain a better understanding of the winter distribution and relative abundance of groundfish species in the Cabot Strait area during winter. The Cabot Strait comprises several divisions and unit areas of the Northwest Atlantic Fisheries Organization (NAFO), that are used for fisheries management of the various fish stocks (Figure 2). The surveys conducted in 1996 and 1997 were also used to collect specimens or tissues for analyses related to a study of cod stock mixing in the Cabot Strait area (Chouinard 1994; Campana et al. 1999).

The purpose of this report is to describe the distribution of both commercial and non-commercial marine fish species in the Cabot Strait area using data collected during these surveys. With increasing interest in other uses of the marine environment of the Cabot Strait, (e.g. oil and gas exploration) knowledge of the distribution of marine fish species in this area will be useful to determine potential impacts. The patterns of distribution are compared and discussed with those documented in previous studies.

METHODS

a) Surveys

Surveys were conducted in January of 1994 to 1997. Sample date coverage was from January 14 to 24 in 1994, January 11 to 28 in 1995, January 6 to 22 in 1996, and January 6 to 26 in 1997 (Table 1).

Two research vessels with different bottom trawls were used. The 1994 and 1995 surveys were conducted aboard the CCGS *Alfred Needler* using an Atlantic Western IIA survey trawl (see specifications in Hurlbut and Clay 1990). The 1996 and 1997 surveys were conducted aboard the *Alfred Needler*'s sister-ship, the CCGS *Wilfred Templeman*, using a Campelen 1800 survey trawl (McCallum and Walsh 1994).

Standard demersal fish survey sampling procedures were used during all surveys (for details see Hurlbut and Clay 1990 and Chadwick et al. 2007). Fishing sets using the Atlantic Western IIA survey trawl (1994 and 1995) were of 30 minutes duration at a speed of 3.5 knots, while those with the Campelen 1800 (1996 and 1997) were of 15 minutes duration at a speed of 3.0 knots. Both survey trawls had fine mesh (19 mm) liners in their cod-ends. On board the survey vessels, the catches were sorted and total weights (to 0.01 kg) were recorded for all species. Length frequencies (in 1 cm intervals) were obtained for all fish species caught and detailed sampling for various characteristics (weight (g), sex, maturity, otoliths and tissue samples) was conducted on length-stratified samples of a number of species.

In 1994, the survey focused on waters along the southern edge of the Laurentian Channel (Figure 3). The surveys conducted from 1995 to 1997 were extended to the east to cover both sides of the Channel.

The sampling design for the surveys also differed among years. The 1994 survey followed a stratified random design using the stratification scheme described in Halliday and Koeller (1981). Strata 436, 437, 438, 439, 440, 441, 442 and parts of 444, 446 and 459 were sampled. Subsequent surveys used a grid or lattice sampling scheme, a design which is often used in studies of spatial distribution. The grid units were 10 nautical miles square in 1995 and 12 nautical miles square in 1996 and 1997. In all three years, additional stations were added at the mid-point of the grid mesh in areas previously determined as areas of cod concentration during the winter (200 m contour on the southern edge of the Laurentian Channel and 250 m contour on the northern edge). This was done to ensure that there would be sufficient coverage in areas of steep gradients where concentrations of some species such as Atlantic cod can be found.

b) Analysis

Tow distances with the Western IIA trawl ranged from 1.2 to 2.1 nm in 1994 and 1995, and for the Campelen trawl they ranged from 0.4 to 1.0 nm in 1996 and 1997 (Table 1). We standardized catches of all species to a 1.75 nm tow for catches by the Western IIA trawl and to 0.75 nm for catches by the Campelen trawl, based on the actual distance towed.

The various species were ranked in order of catch by weight over the four years of the survey. The top 25 species in order of importance by weight accounted for 98% of all marine fish catches by weight and 97% by number. The spatial distribution of these 25 species was summarized in terms of weight per tow and numbers per tow.

For the commercial species, separate plots were prepared showing the distribution of catches in numbers of individuals of legal commercial size and those below the minimum regulated size. For most of the species, the majority of individuals below the minimum size would be sexually immature. The minimum sizes used for the commercial species were:

Atlantic cod (*Gadus morhua*):	43 cm
White hake (*Urophycis tenuis*):	45 cm
Redfish (*Sebastes* sp.)	22 cm
American plaice (*Hippoglossoides platessoides*):	30 cm
Greenland halibut (*Reinhardtius hippoglossoides)*:	44 cm
Witch flounder (*Glyptocephalus cynoglossus*):	30 cm
Atlantic herring (*Clupea harengus*):	26 cm

Potential day-night differences in catchability for each vessel-gear combination were examined for the 25 most abundant species caught using the statistical control method described by Benoît and Swain (2003).

Mean sunrise and sunset times for the area and time were used to classify the fishing sets as occurring during the day or during the night. Fishing sets were classified as 'day' sets if they occurred between 07:40 and 16:39 hours (inclusive). Fishing sets at other times were classified as 'night' sets. We estimated the night catchability relative to the day catchability by species and vessel-gear combination using generalized linear models with year-stratum (β1) and time of day (β2; day or night) factors.

$$Y_{ijk} = \exp(\beta 0 + B1_i + \beta 2_j)$$

where Y_{ijk} is the catch in numbers in set k, for time of day j and in year-stratum i. A Poisson error distribution was assumed. Following Benoît and Swain (2003), randomization tests (1,000 iterations) were used to assess the statistical significance of the time of day effect. The analyses only considered year-stratum in which the species was caught at least once and where both day and night tows were conducted.

Occasional large catches can have a large influence on estimates of relative catchability (Benoît and Swain 2003). This was examined by first conducting the analyses with all values, and then by redoing the analyses after removing a progressively larger percentile of the largest day and night catches by species. Successively, the largest 1st to 10th percentile of the catches were removed. This analysis suggested that removing the top 1% of catches was sufficient to stabilize the relative catchability for all analyses except for cod caught by the CCGS *Alfred Needler*, where it was necessary to remove the top 5%. Where statistically significant differences in catchability between day and night were found, night catches were adjusted to day equivalents. This was done by multiplying the night catches by $1/\exp(\beta 2_1)$. No attempt was made to standardize the catches for differences in fishing efficiency associated with the two vessel-gear combinations. Results are presented separately for each year and comparisons between 1994-1995 and 1996-1997 should take into account potential catchability differences between the two vessel–gear combinations.

The survey catches were contoured using Delaunay triangulation as implemented in the ACON software (ACON 10.3.0, Fisheries and Oceans Canada), and used a blanking distance of 0.75 degrees. Contour intervals for weight per tow were determined for each species separately. The range of the observations of catch in weight was divided into

approximately equal intervals on the logarithmic scale. For numbers per tow, the same contour intervals were used for all species using the data range of the species with the largest catch in numbers. This was done to allow for comparison of the relative catches within a survey among species.

RESULTS AND DISCUSSION

The total number of stations sampled each year was: 70, 164, 138, and 104 in 1994 to 1997 respectively (Table 1). Because the duration of the time interval defined as night (i.e. 16:40 to 07:39 hrs.) was 6 hours longer than the duration of the time interval defined as day (i.e. 07:40 to 16:39 hrs.), there were considerably more sets made during the night each year than during the day (Table 1).

It is recognized that the Atlantic Western IIA trawl used by the CCGS *Alfred Needler* likely had different catchability for a number of species than the Campelen 1800 trawl used by the CCGS *Wilfred Templeman*. Such catchability differences have been documented between the Campelen 1800 and other survey trawls for some species (see Warren 1997). As previously mentioned, in this analysis, no corrections for differences in vessels or gears were made.

Over the course of the four surveys, more than 90 fish species were identified (Table 2). More species / species groups were sampled in 1996 and 1997, 79 and 76 respectively, than in 1994 and 1995, 56 and 63 respectively (Table 2). A number of species / species groups were quite rare, being captured in less than 10% of the sampled stations in any of the four years (Table 2).

The Cabot Strait appears to be an important area of distribution for many fish species during January. Survey trawl catches greater than 100 kg were widespread throughout the area in depths of 150 m and deeper (Figure 4). Generally, catches were lower in shallower waters and the highest catches tended to be found on the southern and northern slopes of the Laurentian Channel.

a) Diel differences in catchability

There were few cases (n = 5) of significant ($p < 0.05$) diel differences in the catchability for the species examined (Table 4). Atlantic wolffish and smooth skate on CCGS *Wilfred Templeman* as well as thorny skate on CCGS *Alfred Needler* had a lower catchability during the day than during the night. On the other hand, on both vessels, more lumpfish were caught during the day than during the night. The differences in catchability estimated for these species had the same tendency relative to time of day as those estimated for surveys conducted in the southern Gulf of St. Lawrence in September (Benoît and Swain 2003). Similarly, Casey and Myers (1998a) found that higher catches of wolffish and skates occurred during the night on the Grand Banks of Newfoundland. Surveys in that area also recorded significantly higher catches of lumpfish during the day.

The results suggest that there may be less difference in the diel catchability of cod during winter in the Cabot Strait than in the southern Gulf of St. Lawrence during summer (Benoît and Swain 2003). The lack of a significant difference in day and night catches for CCGS *Alfred Needler* for Atlantic halibut, winter skate, longhorn sculpin, sea raven, and spiny dogfish during these winter surveys compared to the September survey may be due to the low abundance of these species during the January surveys.

b) Distribution of primary commercial species

Atlantic cod (*Gadus morhua*)

Concentrations were found along the 200 m isobath on the southern edge of the Laurentian Channel and in slightly deeper water along the northern edge of the Laurentian Channel (Figures 5a and 5b). Areas of concentrations were around St. Paul's Island and off Smokey Bank on the southern edge. Along the northern edge of the Laurentian Channel, concentrations were located in waters off Port-aux-Basques (Newfoundland) and south of Burgeo Bank. Generally, smaller cod tended to be found in shallower water and at higher latitude than larger cod (Figures 5c and 5d; Chouinard 1994).

It has long been known that cod from both the southern and northern Gulf of St. Lawrence overwinter in the Cabot Strait area (Templeman 1962). Numerous tagging studies conducted in both the southern and northern Gulf of St. Lawrence as well as the results of winter tagging studies in Sydney Bight have documented the general seasonal migration pattern of cod (McKenzie 1956; McCracken 1959; Templeman and Fleming 1962; Jean 1963; Jean 1964; Martin and Jean 1964; Minet 1976; Templeman 1974; Gascon et al. 1990). Cod from these populations are found inside the Gulf of St. Lawrence during summer (Halliday and Pinhorn 1982). Although cod likely start to migrate within the waters of the southern Gulf of St. Lawrence (NAFO 4T) during September and October, they do not appear to reach the waters of the Cabot Strait until November and December. Based on data from the commercial fishery, Lambert (1993) and Sinclair and Currie (1994) showed that cod from the southern Gulf moved into the Sydney Bight starting in November in the late 1980s and early 1990s. This information resulted in a change to the management unit for southern Gulf of St. Lawrence cod (formerly 4T and 4Vn (January to April)) to include as well catches from the months of November and December in 4Vn (Sinclair et al. 1994). Comeau et al. (2002b) found that the timing of the migration to the Cabot Strait, as indicated by the timing of peak catches off the west coast of Cape Breton, in the 1990s was about a month earlier than in the 1970s (i.e. November 1 rather than November 30 previously). Some of the cod captured during the January surveys in the southernmost portions of the southern edge of the survey area (4Vsb) may be from the eastern Scotian Shelf cod stock. However, in some years, significant catches from this area during the period from January to April have been attributed to the southern Gulf cod stock (Hanson 1995). Similarly, cod from the northern Gulf of St. Lawrence migrate to the northern edge of the Laurentian Channel in the Cabot Strait in late fall and return to the waters of the Gulf of St. Lawrence in April-May (Templeman 1962).

A study of the potential mixing of overwintering cod populations in the Cabot Strait showed that cod catches in the 1996 and 1997 surveys (described here) belonged primarily to two main populations: the southern Gulf of St. Lawrence cod stock (NAFO 4T and 4Vn (November to April)) and the northern Gulf of St. Lawrence (NAFO 3Pn, 4RS) (Campana et al. 1999). The analyses of trace metals in cod otoliths showed that the concentrations of cod that were found along the southern edge were primarily from the southern Gulf stock, while those from the northern edge were mainly from the northern Gulf stock (3Pn, 4RS), and that there was little mixing between the two stocks (Campana et al. 1999).

On the southern edge of the Laurentian Channel, some of the cod catches probably included fish from the 4Vn resident stock. Comeau et al (2002a) showed that 4Vn resident cod also overwinter in 4Vn. However, owing to it's low population abundance (spawning stock biomass less than 2,500 t in the early 2000s; Mohn et al. 2001), the 4Vn resident stock was thought to comprise only a small fraction of the catches in these surveys. This assumption was confirmed by analyses of vertebral number in the over-wintering area (Swain et al. 2001) which suggested that only about 2% of cod in the over-wintering areas could be attributed to the 4Vn resident stock. Consistent with Campana et al. (1999), Swain et al. (2001) also showed that there is little mixing between the northern and southern Gulf of St. Lawrence cod stocks, as very few northern Gulf cod were found on the south side of the Laurentian Channel and vice versa.

Tagging studies (Gascon et al. 1990; Bérubé and Fréchet 2001) as well as the trace metal analyses of cod otoliths (Campana et al. 1999) also indicated significant mixing of the 3Pn, 4RS (northern Gulf of St. Lawrence) and 3Ps (St. Pierre Bank) cod populations in the area of Burgeo Bank in 3Ps during the winter. Currently, the management unit for the northern Gulf of St. Lawrence, which excludes 3Ps, does not appear to circumscribe the full range of the winter distribution of northern Gulf of St. Lawrence cod (Chouinard 2000).

The distribution of cod on the southern edge of the Laurentian Channel during January was also consistent with the results of seasonal surveys conducted in the southeastern Gulf in 1986 and 1987. During the seasonal surveys conducted in January 1987, cod were found almost exclusively along the edge of the Laurentian Channel near the northern tip of Cape Breton (Clay 1991; Darbyson and Benoît 2003). Cod catches in the southeastern Gulf of St. Lawrence, which were common during the summer months, were low in January.

There was a gradient in the size distribution of cod from north to south (Figs. 5c and 5d) as previously described by Jean (1964). This suggests that larger cod from the southern Gulf tend to migrate further than the smaller (often immature) fish.

Another feature of the January distribution of cod in the Cabot Strait is the striking consistency in the location of some of the aggregations in the four years of the survey. In particular, cod catches were high in all four years in the waters around St. Paul's Island

on the southern edge of the Laurentian Channel. On the northern side of the Cabot Strait, catches of larger cod were also high in the area south of Burgeo Bank in the two years when this area was surveyed. These areas would appear to be particularly important for cod in January.

Using data collected during the 1994 and 1995 surveys, Swain et al. (1998) found that southern Gulf cod in the Cabot Strait in January occupy deeper (374-426 m) and warmer (5.2-5.4°C) waters than they do when they are distributed in their summer feeding grounds in the southern Gulf. Castonguay et al. (1999) found similar results for the northern Gulf population. Cod also tend to be more aggregated during the winter than they are during the summer (Swain et al. 2001).

White hake (*Urophycis tenuis*)

The highest concentrations of white hake were found on the southern edge of the Laurentian Channel, primarily in waters from 200-300 m deep (Figures 6a and 6b). On the northern edge of the Channel, a concentration was apparent south of Burgeo Bank at the southern extremity of Hermitage Channel. Fish larger than 45 cm tended to be found in deeper waters than smaller fish (Figures 6c and 6d) as described by Herder et al. (2005).

The only tagging study of white hake ever conducted (Kohler 1971) indicated that some white hake from the inshore, shallow waters of the southern Gulf migrated to the deeper waters of the Cape Breton Trough and possibly to the Laurentian Channel. The distribution of white hake in winter during the January surveys is consistent with the migration patterns inferred from seasonal surveys conducted in the southern Gulf of St. Lawrence in the mid-1980s (Clay 1991; Hurlbut and Benoît 2001; Darbyson and Benoît 2003). Clay (1991) suggested that the Laurentian Channel is the probable overwintering area for hake from both the southern and northern Gulf of St. Lawrence. Morin and Hurlbut (1994) conducted an analysis of survey data for the northern and southern Gulf (fall and winter) and found that hake increasingly occupy the deeper, eastern portion of the Gulf in winter. The distribution appeared to be continuous with the Cabot Strait.

While most previous studies correctly indicated that white hake from the southern Gulf migrate to the Laurentian Channel to over-winter, the January surveys showed that the bulk of the white hake distribution was found in the Sydney Bight (NAFO 4Vn - southern portion of the Laurentian Channel). The current management unit for white hake that reside in the southern Gulf during the summer (NAFO Div. 4T) does not account for this overwintering distribution. Therefore, winter fisheries conducted in the Cabot Strait (particularly Sydney Bight) could harvest white hake from the southern Gulf management unit. The commercial fishery for white hake in the southern Gulf has been under moratorium since 1995 due to low abundance, and catches of white hake in the Sydney Bight have been greatly reduced because of restrictions on the cod and redfish fisheries in the area (Hurlbut and Poirier 2001). However, if winter fisheries are allowed in the Sydney Bight in the future, the potential impact on white hake should be considered.

Redfish (*Sebastes* sp.)

Three species of the genus *Sebastes* occur in the waters of Atlantic Canada: *S. mentella* – deepwater redfish, *S. fasciatus* – Acadian redfish and *S. norvegicus* (previously *S. marinus*) – golden redfish (Scott and Scott 1988; St-Pierre and de Lafontaine 1995; Sévigny et al. 2000). Because redfish species cannot be easily separated (Atkinson 1984), catches in the January survey are reported for the genus as a group. In the area of the Cabot Strait, redfish catches have been shown to be composed almost exclusively of *S. mentella* and *S. fasciatus*. *S. norvegicus* has rarely been found in this area. For management purposes, 3 groups are recognized: Units 1, 2 and 3 redfish. Redfish in the Gulf of St. Lawrence form part of the Unit 1 redfish management area, comprising NAFO Divisions 4RST (year-round) and 3Pn and 4Vn from January to May. In January, Unit 2 redfish are considered to be found in 4Vs and 3Ps (DFO 2000). There are uncertainties about the migrations of redfish between the Gulf of St. Lawrence and adjacent areas, and about the integrity and reproductive isolation of these groups.

Unlike white hake, redfish concentrations tended to be found in the eastern portions of the Laurentian Channel, in the Cabot Strait, as previously described by Morin et al. (1994) and Gascon (2003). Concentrations were present in areas south of Port-aux-Basques, south of Rose Blanche Bank and south of Burgeo Bank (Figures 7a and 7b). There was a clear difference in the areas occupied by small (< 22 cm) and large redfish (22 cm+). Small redfish tended to be found in waters of 200 m and less (Figure 7c) and were rare in the middle of the Laurentian Channel. In contrast, large redfish were found primarily in waters deeper than 200 m (Figure 7d). These differences may be due to species composition rather than to ontogenetic variation: *S. fasciatus* are usually found in shallower depths than *S. mentella* (Scott and Scott 1988; Atkinson 1984 and Campana et al. 2007).

As for cod, white hake and several other marine fish species from the Gulf of St. Lawrence, redfish also undertake an extensive seasonal migration (Atkinson 1984). Historical survey and fishery data (Atkinson 1984 and Morin et al. 1994) have shown that redfish are widespread in the deep water of the Gulf of St. Lawrence during the summer, while winter concentrations of redfish are located primarily in the Cabot Strait. The surveys conducted from 1994-1997 showed that the largest concentrations in terms of biomass were also found in the Cabot Strait. In terms of the distribution of size groups, our results were similar to those of Atkinson (1984) and Campana et al. (2007): small redfish were found in shallower waters than large redfish.

American plaice (*Hippoglossoides platessoides*)

American plaice were widely distributed along the southern portion of the Laurentian Channel in waters deeper than 200 m. Catches off the south coast of Newfoundland were generally low (Figures 8a and 8b). Areas of concentration included the areas to the north and east of St. Paul's Island and off the Louisburg Holes. There did not seem to be

significant differences in the distribution of small and large American plaice (Figures 8c and 8d).

American plaice from the southern Gulf are also known to migrate to the deep waters of the Laurentian Channel and to some extent to Sydney Bight (NAFO 4Vn) in November and December (Powles 1965; Swain et al. 1998). However, the migration does not seem to be as extensive as it is for cod. Clay (1991) found significant catches of American plaice in the deep waters of the Laurentian Channel northwest of the Magdalen Islands in January and concluded that the migration was mostly to deep waters. Similarly, analyses of seasonal survey catches in November 1990 and April 1991 also revealed important concentrations of American plaice in the Laurentian Channel between the Gaspé Peninsula and the Magdalen Islands (Darbyson and Benoît 2003). Although the area of highest concentration in the January surveys reported here was generally in the vicinity of St. Paul's Island, significant catches were also made at the northern limit of the survey. This would suggest that American plaice are still present in the Gulf in January consistent with the view of Clay (1991). Few plaice were found in depths less than 200 m. Similar to Atlantic cod, American plaice have been found to occupy deeper, warmer waters in the winter than in the summer (Swain et al. 1998). Swain et al. (1998) hypothesized that their presence in warmer water (5.2 to 5.4°C in January) during the winter, a time when they cease feeding, may be linked to gonad development that precedes their spring spawning migration to the shallower waters of the southern Gulf of St. Lawrence.

Greenland halibut (*Reinhardtius hippoglossoides*)

Greenland halibut (commonly called turbot) in the Gulf of St. Lawrence are considered to be a unit stock isolated from the main northwest Atlantic population found east and north of Newfoundland's Grand Bank (DFO 2008).

Greenland halibut catches were common in the January surveys and exhibited a relatively uniform distribution in the deeper waters (> 200 m) of the Laurentian Channel throughout the area surveyed (Figures 9a and 9b). There were no obvious differences in the distribution of small (< 44 cm) and large turbot (44 cm+) (Figures 9c and 9d).

In summer (August/September), Greenland halibut in the Gulf of St. Lawrence are primarily found in the deep waters of the western part of the Laurentian Channel (St. Lawrence Estuary) and Anticosti Channel (Morin and Bernier 2003; Benoît et al. 2003). In winter, Bowering (1982) found Greenland halibut distributed widely throughout the northern Gulf of St. Lawrence, but noted the presence of concentrations of pre-spawners in deep water off southwestern Newfoundland. The widespread distribution observed in the January surveys of the Cabot Strait from 1994 to1997 suggests that a portion of this stock may overwinter in the deeper waters of the Laurentian Channel at the entrance to the Gulf of St. Lawrence.

Witch flounder (*Glyptocephalus cynoglossus*)

Witch flounder (commonly called greysole) catches were common throughout the deeper waters of the Laurentian Channel. Concentrations were apparent in two distinct areas: inside the Gulf off the western coast of Newfoundland and off the Louisburg Holes (Figures 10a and 10b). No apparent differences were noted in the distribution of small (< 30 cm) and large witch flounder (Figures 10c and 10d).

During summer, witch flounder are distributed throughout the deep channels of the Estuary and Gulf of St. Lawrence (Morin and Hurlbut 1994; Swain and Poirier 2001; DFO 2005). Juveniles occupy these deep waters throughout the year, but the adults move into shallower waters (100-200 m) to feed in the summer. In research surveys of the Gulf of St. Lawrence conducted during the summer, concentrations of adult witch flounder are apparent along the west coast of Newfoundland, particularly in St. George's Bay, along the west coast of Cape Breton in the Cape Breton Trough, and extending into the western Magdalen Shallows along the Chaleur Trough and Shediac Valley (Benoît et al. 2003). In winter, dense pre-spawning aggregations have been reported in the lower Esquiman Channel and eastern Laurentian Channel (Bowering and Brodie 1984). The January surveys conducted from 1994 to 1997 indicated that aggregations of both adult and juvenile witch flounder in the deep waters of the Laurentian Channel extended well into the Cabot Strait .

Atlantic herring (*Clupea harengus*)

Herring catches were more localized than the catches of other species. Significant catches were made in waters less than 200 m deep. The largest concentrations were generally found in the northern section of the area near St. Paul's Island. Other significant catches were recorded near the Louisburg Holes (Figures 11a and 11b). Concentrations of small herring appeared to be found in shallower areas than those where larger herring were found, but their general areas of distribution were similar (Figures 11c and 11d).

The herring concentrations found near St. Paul's Island are thought to have originated from spawning beds in the southern Gulf of St. Lawrence. Herring undergo an annual migration from the southern Gulf to over-wintering sites off the eastern coast of Cape Breton in 4Vn. Based on tagging studies conducted in the late 1960's and early 1970's, it was considered that some herring from the southern Gulf also over-winter along the southern coast of Newfoundland (Winters and Beckett 1974). No major concentrations of herring were found in that area but the surveys did not extend into inshore waters.

c) Distribution of other species

Atlantic hagfish (*Myxine glutinosa*) were caught in low numbers at depths greater than 200 m (Figures 12a and 12b). Hagfish normally inhabit and burrow into soft muddy bottoms. Catches by the CCGS *Wilfred Templeman* were higher than those by the CCGS *Alfred Needler*. Catchability for this species is likely to have been higher with the Campelen 1800 trawl than with the Western IIA because the Campelen trawl has smaller

ground gear and smaller mesh in its mouth. In summer, the largest catches in the Gulf of St. Lawrence are usually made in the estuary of the St. Lawrence River and in the Laurentian Channel, particularly off the Gaspé Peninsula (Atkinson 1986; Benoît at al. 2003; Darbyson and Benoît 2003). As well, aggregations are usually found north of St. Paul's Island. The distribution of hagfish observed in January was relatively continuous. It is not known whether this species undertakes an overwintering migration.

Several species of cartilaginous fish were encountered frequently during the surveys. Black dogfish (*Centroscyllium fabricii*) were widely distributed in the middle of the Laurentian Channel (> 200 m) but the largest aggregations were present in the southern part of the survey areas (Figures 13a and 13b). Templeman (1963) reported that this species was found on the northern side of the Cabot Strait. During the summer, aggregations of this species in the Gulf of St. Lawrence are primarily found in the deep waters of the western part of the Laurentian Channel (St. Lawrence Estuary and in the area between the Gaspé Peninsula and Anticosti Island) (Atkinson 1986; Benoît et al. 2003). Aggregations of black dogfish have been described in the Laurentian Channel in the Cabot Strait during the spring, extending from south of Rose Blanche Bank to the southern tip of St. Pierre Bank (Simpson and Kulka 2001), and during the summer in the Cabot Strait south of Rose Blanche Bank (Bourdages et al. 2003). Seasonal surveys conducted in the southern Gulf of St. Lawrence (Darbyson and Benoît 2003) showed that black dogfish were present on the southern edge of the Laurentian Channel east of the Gaspé Peninsula in all months. However, they were only present near the tip of Cape Breton in January and May. These results suggest the possibility of a seasonal migration to and from the Cabot Strait, however the current published literature and the results of this work do not provide a clear picture.

Catches of spiny dogfish (*Squalus acanthias*) were infrequent during the surveys and tended to be restricted to the area south of latitude 47° north (Figures 14a and 14b). A recent analysis of research vessel survey distributions of spiny dogfish on the Scotian Shelf, southern Gulf of St Lawrence, and off southern Newfoundland indicated that dogfish move offshore into deeper, warmer waters in the winter, and during the summer their distributions tend to be throughout coastal waters, including on shallow banks (DFO 2007). In all areas, spring distributions were further offshore (or deeper) than summer distributions. Templeman (1984) reported that spiny dogfish may overwinter off the coast of southern and eastern Newfoundland. Tagging studies suggest that there are both migratory and resident stock components in the northwest Atlantic (DFO 2007).

Four species of skates were encountered during the January surveys. Barndoor skate (*Dipturus laevis* formerly *Raja laevis*) were found in small numbers, primarily near Rose Blanche Bank off the southwest coast of Newfoundland (Figures 15a and 15b). The range of this species typically extends from the southern Grand Banks and southern Gulf of St. Lawrence to North Carolina (Collette and Klein-MacPhee 2002). Simon et al. (2002) examined the distribution from surveys conducted in the Canadian Atlantic and found that most catches were made in waters deeper than 100 m. In the Cabot Strait, their study indicated the presence of barndoor skate in waters south of Burgeo Bank. The specimens caught in the January 1994-1997 surveys were found further to the west, primarily south

of Rose Blanche Bank. Casey and Myers (1998b) considered this species to be close to extinction on the continental shelf from Newfoundland to New England. Smooth skate (*Malacoraja senta* formerly *Raja senta*) and thorny skate (*Amblyraja radiata* formerly *Raja radiata*) were widely encountered during the surveys. The main areas of concentration were the southern edge of the Laurentian Channel from north of St. Paul's Island to south of the Louisburg Holes (Figures 16a and 16b and 17a and 17b). On the northern side of the Laurentian Channel, the areas of concentration were near Burgeo Bank and off St. Pierre Bank. Both species were found to be widely distributed in the Gulf of St. Lawrence in surveys reported in Atkinson (1986). In the southern Gulf, the smooth skate tends to be found in deeper waters (> 150 m) in surveys conducted during the summer (Benoît et al. 2003). From the seasonal surveys conducted in the southern Gulf of St. Lawrence in the late 1980's (Darbyson and Benoît 2003), it is unclear whether there is a seasonal migration of smooth skate, however, the data on thorny skate suggests that they definitely migrate to the deeper waters of the Laurentian Channel (see also Clay 1991). Finally, the distribution of winter skate (*Leucoraja ocellata* formerly *Raja ocellata*) was very patchy. Catches were concentrated in two areas: around St. Paul's Island and around the Louisburg Holes (Figures 18a and 18b). This species is typically found in shallow waters (generally < 40 m) during the summer in the southern Gulf (Clay 1991), and very rarely in deeper waters (Atkinson 1986). However, seasonal surveys conducted in late fall, early winter and early spring in the southern Gulf indicated that the species is found in deeper waters during those times of the year (Darbyson and Benoît 2003). Clay (1991) interpreted the change in distribution to represent a migration to deeper waters. Our results indicate that winter skate are found in the Cabot Strait in January but tend to be concentrated on both sides of the Laurentian Channel in waters deeper than 200 m. Both winter and thorny skates from the southern Gulf of St. Lawrence have experienced a significant decline in abundance over the last 30 years (Swain et al. 2005).

During the surveys, capelin (*Mallotus villosus*) were found throughout the area but did not appear to be found consistently in any particular location from year to year (Figures 19a and 19b). Capelin is a circumpolar species and occurs from Hudson Bay to as far south as Cape Cod on the east coast of North America (Collette and Klein-MacPhee 2002). Capelin spawn on beaches during the summer and then move offshore. Their abundance in the southern Gulf of St. Lawrence and eastern Scotian Shelf was historically low but increased after the late 1990's, and they became widely distributed in these two areas during the 1990s (Frank et al. 1996; Benoît et al. 2003).

The common grenadier or marlin-spike (*Nezumia bairdii*) is a deep-water species (> 90 m) and was widely encountered in the Laurentian Channel in waters deeper than 200 m (Figures 20a and 20b). Atkinson (1986) and Benoît et al (2003) also found the species to be very common in the deeper (> 200 m) waters of the Gulf of St. Lawrence during the summer.

Few Atlantic halibut (*Hippoglosssus hippoglossus*) were caught during the January surveys and the location of the catches differed between surveys (Figures 21a and 21b). Halibut move from shallower waters in summer to deeper waters in winter (Collette and

Klein-MacPhee 2002), with smaller fish moving farther than larger fish (DFO 2006). During the summer they can be found in very shallow water (< 50 m) in the southern Gulf of St. Lawrence around the Magdalen basin and in deeper water along the southern edge of the Laurentian Channel (Benoît et al. 2003; DFO 2011), as well as in waters deeper than 200 m (Bourdages et al. 2003) in the northern Gulf of St. Lawrence.

Longhorn sculpin (*Myoxocephalus octodecemspinosus*) catches were made in waters less than 200 m deep, primarily in the northern portion of the survey areas (Figures 22a and 22b). This species is normally found nearshore in depths less than 50 m in the southern Gulf of St. Lawrence during summer (Benoît et al. 2003). Seasonal surveys conducted in the southern Gulf of St. Lawrence did not suggest that this species undertakes a seasonal migration to deeper waters for the winter (Darbyson and Benoît 2003). However, the significant catches during January 1994 to 1997 along the slope of the Laurentian Channel suggest that there may be localized movements to deeper waters in some areas.

The highest densities of lumpfish (*Cyclopterus lumpus*) were recorded on Burgeo Bank in 1996 and 1997 (Figures 23a and 23b). Other important areas were off Codroy (western Newfoundland) and near the Louisburg Holes. Winter surveys conducted in areas 3Pn and 4RS from 1990 to 1992 found the highest densities just west of Burgeo Bank at the eastern limit of the survey area (Chouinard et al. 1992). During the summer, lumpfish can be found over the Magdalen Shallows (Benoît et al. 2003). Adults tend to be found in shallower waters during the spawning season but move offshore thereafter (Collette and Klein-MacPhee 2002).

Monkfish (*Lophius americanus*) were infrequently caught (Figures 24a and 24b). The catches tended to be distributed along the southern edge of the Laurentian Channel in water deeper than 200 m from 1994-1996. The locations of the catches in this area were similar to the locations of catches made during surveys conducted in the summer of 1999 and 2000 (Branton and Black 2002). However, in 1997 the distribution tended to be more widespread. In spring surveys conducted along the southern and eastern coast of Newfoundland (NAFO 3LMNOP) from 1986 to 2000, monkfish were caught in the Laurentian Channel and around Burgeo Bank (Simpson and Kulka 2001). In the Gulf of St. Lawrence, the species is caught infrequently (Atkinson 1986; Benoît et al. 2003) and is generally found in waters deeper than 100 m.

Catches of Pollock (*Pollachius virens*) were generally low but were observed throughout the area (Figures 25a and 25b). While the range of the species extends from Hudson and Davis Straits to North Carolina (Collette and Klein-MacPhee 2002), the species does not appear to be widely distributed in the Gulf of St. Lawrence. Survey catches in the southern Gulf in September tend to be located along the edge of the Laurentian Channel, with occasional catches at the entrance to the Cape Breton Trough (Benoît et al. 2003). Seasonal surveys in the southern Gulf (Darbyson and Benoît 2003) indicated that pollock can be found in these areas in almost all seasons.

Few sea raven (*Hemitripterus americanus*) were caught and the catches occurred primarily in shallow water on both sides of the Laurentian Channel (Figures 26a and

26b). During summer, in the southern Gulf of St. Lawrence, this species is generally found in inshore waters < 50 m (Benoît et al. 2003). Seasonal surveys conducted in the southern Gulf of St. Lawrence tended to suggest a seasonal migration to deeper waters (≥ 200 m) during the winter (Darbyson and Benoît 2003).

The largest catches of Atlantic argentine (*Argentina silus*) were observed in the vicinity of Burgeo and St. Pierre Banks in 1996 and 1997 (Figures 27a and 27b). This area was not surveyed in 1994 and 1995. This species is found on both sides of the Atlantic in deep water along the continental slopes (Collette and Klein-MacPhee 2002). There is little published information on the distribution of this species in the Canadian Atlantic.

Atlantic wolffish (*Anarhichas lupus*) tended to be caught in waters less than 200 m deep (Figures 28a and 28b). The largest catches in the surveys were recorded near Rose Blanche and around Burgeo Bank. On the southern side of the Laurentian Channel, the largest catches were observed in the vicinity of the Louisburg Holes (Figures 28a and 28b). No catches were made in the middle of the Laurentian Channel. Similarly, summer surveys conducted in the southern Gulf of St. Lawrence (Benoît et al. 2003; Darbyson and Benoît 2003), Scotian-Shelf (Branton and Black 2002) and northern Gulf of St. Lawrence-Cabot Strait (Bourdages et al. 2003) indicated that most catches of Atlantic wolffish were made in waters less than 200 m deep. This may suggest that Atlantic wolffish from the northern and southern Gulf of St. Lawrence are different populations.

Finally, catches of longfin hake (*Phycis chesteri*) were widespread throughout the deeper waters of the Laurentian Channel (Figures 29a and 29b). Data from surveys conducted in the spring in NAFO divisions 3LMNOP indicate that catches of longfin hake were amongst the highest in the Laurentian and Hermitage Channels (Simpson and Kulka 2001). In surveys of the Gulf of St. Lawrence, the highest concentrations during summer were found off the western tip of Newfoundland (Port-au-Basques) in waters > 340 m deep (Atkinson 1986). Survey data for the southern Gulf of St. Lawrence (Benoît et al 2003; Darbyson and Benoît 2003) also indicates that the distribution of this species is mainly restricted to the edge of the Laurentian Channel. The various surveys and the data presented here suggest that the waters of the Laurentian Channel are an important distribution area for longfin hake in Atlantic Canada.

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REFERENCES

Atkinson, D.B. 1984. Distribution and abundance of beaked redfish in the Gulf of St. Lawrence, 1976-81. J. Northw. Atl. Fish. Sci. 5: 189-197.

Atkinson, D.B. 1986. Distribution of some non-commercial finfish in the Gulf of St. Lawrence, 1976-1981. Can. Tech. Rep. Fish. Aquat. Sci. 1423: 56 p.

Benoît, H.P., and Swain, D.P. 2003. Accounting for length- and depth-dependent diel variation in catchability of fish and invertebrates in an annual bottom-trawl survey. ICES J. Mar. Sci. 60: 1298-1317.

Benoît, H.P., Darbyson, E., and Swain, D.P. 2003. An atlas of the geographic distribution of marine fish and invertebrates in the southern Gulf of St. Lawrence based on annual bottom-trawl surveys (1971-2002). Can Data Rep. Fish. Aquat. Sci. 1112: iii + 185 p.

Bérubé, M., and Fréchet, A. 2001. Sommaire du programme de marquage des pêches sentinelles du nord du golfe avec une emphase sur les re-captures provenant des unités de gestion voisines. MPO, Secr. can. consul. sci. Doc. rech. 2001/002 : 24 p.

Bourdages, H., Archambault, D., Morin, B., Fréchet, A., Savard, L., Grégoire F., and Bérubé, M. 2003. Résultats préliminaires du relevé multidisciplinaire des poissons de fond et de crevette d'août 2003 dans le nord du golfe du Saint-Laurent / Preliminary results from the groundfish and shrimp multidisciplinary survey from August 2003 in the northern Gulf of St. Lawrence. CSAS Res. Doc. 2003/078: 68 p.

Bowering, W.R. 1982. Population dynamics of Greenland halibut in the Gulf of St. Lawrence. J. Northwest Atl. Fish. Sci. 3: 141-147.

Bowering, W.R., and Brodie, W.B. 1984. Distribution of witch flounder in the northern Gulf of St. Lawrence and changes in its growth and sexual maturity patterns. N. Am. J. Fish. Manag. 4: 399-413.

Branton, R., and Black, G. 2002. 2002 summer groundfish survey update for selected Scotia-Fundy groundfish stocks. CSAS Res. Doc. 2002/089: 62 p.

Campana, S.E., Chouinard, G.A., Hanson, J.M., and Fréchet, A. 1999. Mixing and migration of overwintering cod stocks near the mouth of the Gulf of St. Lawrence. Can. J. Fish. Aquat. Sci. 56: 1873-1881.

Campana, S.E., Valentin, A., Sévigny, J-M., and Power, D. 2007. Tracking seasonal migrations of redfish (*Sebastes spp.*) in and around the Gulf of St. Lawrence using otolith elemental fingerprints. Can. J. Fish. Aquat. Sci. 64: 6-18.

Casey, J.M., and Myers, R.A. 1998a. Diel variation in trawl catchability: is it clear as day and night ? Can. J. fish. Aquat. Sci. 55: 2329-2340.

Casey, J.M., and Myers. R.A. 1998b. Near extinction of a large, widely distributed fish. Science 281: 690-692.

Castonguay, M., Rollet, C., Fréchet, A., Gagnon, P., Gilbert, D., and Brêthes, J.-C. 1999. Distribution changes of Atlantic cod (*Gadus morhua* L.) in the northern Gulf of St Lawrence in relation to an oceanic cooling. ICES J. Mar. Sci. 56: 333-344.

Chadwick, E.M.P., Brodie, W., Clark, D., Gascon, D., and Hurlbut, T. 2007. History of annual multi-species trawl surveys on the Atlantic Coast of Canada / Historique des relevés de chalut multi-spécifiques annuels sur la côte Atlantique du Canada. AZMP Bulletin No. 6 (April 2007): p. 25 – 42: http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/publications-eng.html

Chouinard, G.A. 1994. Distribution of groundfish and herring during the 1994 Cabot Strait survey. DFO Atl. Fish, Res. Doc. 94/68: 24 p.

Chouinard, G.A. (ed.). 2000. Report of the Cod Mixing Workshop, 16-17 October 2000, St. John's, Nfld. DFO Can. Stock Assess. Sec. Proc. Series 2000/27: 18 p.

Chouinard, G.A., Hurlbut, T., Morin, B., Baird, J., and Bishop, C. 1992. The lumpfish (*Cyclopterus lumpus*) resource in Atlantic Canada. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 92/106: 19 p.

Clay, D. 1991. Seasonal distribution of demersal fish (Osteichthyes) and skates (Chondrichthyes) in the southeastern Gulf of St. Lawrence. p. 241-259. *In* J.-C. Therriault (ed.). The Gulf of St. Lawrence: small ocean or big estuary? Can. Spec. Publ. Fish. Aquat. Sci. 113.

Collette, B.B. and Klein-MacPhee, G. 2002. Bigelow and Schroeder's Fishes of the Gulf of Maine, 3rd. ed. Smithsonian Institution Press. Washington., xxxiv + 748 p.

Comeau, L.A., Campana, S.E., and Castonguay, M. 2002a. Automated monitoring of a large-scale cod (*Gadus morhua*) migration in the open sea. Can. J. Fish. Aquat. Sci. 59: 1845-1850.

Comeau, L.A., Campana, S.E., and Chouinard, G.A. 2002b. Timing of Atlantic cod (*Gadus morhua* L.) seasonal migrations in the southern Gulf of St. Lawrence: inter-annual variability and proximate control. ICES J. Mar. Sci. 59: 333-351.

Darbyson, E., and Benoît, H.P. 2003. An atlas of the seasonal distribution of marine fish and invertebrates in the southern Gulf of St. Lawrence. Can. Data Rep. Fish. Aquat. Sci. 1113: iii + 294 p.

DFO. 2000. Status of redfish stocks in the Northwest Atlantic: redfish in units 1,2 and in Division 3O. DFO Science Stock Status Report – A1-01 (2000).

DFO. 2005. Witch Flounder (Divs. 4RST). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/011.

DFO. 2006. Atlantic Halibut on the Scotian Shelf and Southern Grand Banks (Div. 3NOPs4VWX). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/038.

DFO, 2007. Assessment of Spiny Dogfish in Atlantic Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/046.

DFO. 2008. Assessment of the Greenland Halibut Stock in the Gulf of St. Lawrence (4RST) in 2007. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2008/044.

DFO. 2011. Stock Assessment of Atlantic Halibut of the Gulf of St. Lawrence (NAFO Division 4RST) for 2009 and 2010. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/012.

Frank, K.T., Carscadden, J.E., and Simon, J.E. 1996. Recent excursions of capelin (*Mallotus villosus*) to the Scotian Shelf and Flemish Cap during anomalous hydrographic conditions. Can. J. Fish. Aquat. Sci. 53: 1473-1486.

Gascon, D. (Editor). 2003. Redfish multidisciplinary research zonal program (1995-1998): final report. Can. Tech. Rep. Fish. Aquat. Sci. 2462: iv + 68 p.

Gascon, D., Apparicio, M., and Mercille, B. 1990. Estimation du mélange entre les stocks de morues du nord du Golfe du St. Laurent (Div. 3Pn, 4RS) et les stocks adjacents (2J3KL, 3Ps, 4T-Vn (jan.-avril)) à partir des résultats de marquage. Com. Sci. Cons. Pêches Can. Atl. Doc. Rech. 90/ 61: 25 p.

Halliday, R.G., and Koeller, P.A. 1981. A history of Canadian groundfish trawling surveys and data usage in ICNAF Divisions 4TVWX. *In* W.G. Doubleday and D. Rivard [ed.] Bottom trawl surveys. Can. Spec. Pub. Fish. Aquat. Sci. 58: 27-41.

Halliday, R.G., and Pinhorn, A.T. 1982. The groundfish resource in the Gulf of St. Lawrence. Can. Tech. Rep. Fish. Aquat. Sci. 1086: iv + 16 p.

Hanson, J.M. 1995. Separation of catches of two Atlantic cod stocks in an otter trawl fishery by application of the EM algorithm. North Am. J. Fish. Manage. 15: 277-289.

Herder, E.C., Methven, D.A., and Hurlbut, T.R. 2005. Long-term changes in size-depth distributions of *Urophycis tenuis* white hake in the southern Gulf of St Lawrence and Cabot Strait. J. Mar. Biol. Ass. UK. 85: 1203-1210.

Hurlbut, T., and Benoît, H. 2001. The seasonal distribution of selected marine fish in the southeastern Gulf of St. Lawrence based on bottom-trawl surveys. DFO Can. Stock Assess. Sec. Res. Doc. 2001/ 116: 71 p.

Hurlbut, T., and Clay, D. 1990. Protocols for research survey cruises within the Gulf Region (demersal fish) (1970-1987). Can. MS Rep. Fish. Aquat. Sci. 2082: 143 p.

Hurlbut, T., and Poirier, G. 2001. The status of white hake (*Urophycis tenuis*, Mitchill) in the southern Gulf of St. Lawrence (NAFO Division 4T) in 2000. DFO Can. Sci. Adv.Sec. Res. Doc. 2001/024: 60 p.

Jean, Y. 1963. Where do Seven Islands cod come from ? Trade News 16(2): 6-7.

Jean, Y. 1964. Seasonal distribution of cod (*Gadus morhua* L.) along the Canadian Atlantic coast in relation to water temperature. J. Fish. Res. Board Can. 21: 429-460.

Kohler, A.C. 1971. Tagging of white hake, *Urophycis tenuis* Mitchill, in the southern Gulf of St. Lawrence. ICNAF Res. Bull. 8: 21-25.

Lambert, T.C. 1993. The timing of the winter migration of 4T cod into 4Vn. DFO Atl. Fish. Res. Doc. 93/25: 24 p.

Martin, W.R., and Jean, Y. 1964. Winter cod taggings off Cape Breton and offshore Nova Scotia banks, 1959-62. J. Fish. Res. Board Can. 21: 215-239.

McCallum, B.R., and Walsh, S.J. 1994. Survey trawl reference manual - Campelen 1800. DFO, Science Branch, P.O. Box 5667, St. John's Nfld, A1C 5X1, 26 p.

McCracken, F.D. 1959. Cod tagging off northern New Brunswick in 1955 and 1956. Fish Res. Bd. Canada Prog. Rept. Atl. Coast Sta. 72: p 8-19.

McKenzie, R.A. 1956. Atlantic cod tagging off the southern Canadian mainland. Bull. Fish. Res. Board Can. 105: 93 p.

Minet, J.-P. 1976. Migration of cod between the northern Gulf of St. Lawrence and the south-western banks of Newfoundland. ICNAF Res. Doc. 76/VI/74, Serial no. 3886.

Mohn, R.K., Beanlands, D., Black, G.A.P., and Lambert, T. 2001. Assessment of status of 4Vn cod (May-October) 2000. DFO Can. Sci. Adv. Sec. Res. Doc. 2001/105: 52 p.

Morin, B., and Bernier, B. 2003. Evaluation de flétan du Groenland (*Reinhardtius hippoglossoides*) du golfe du Saint-Laurent (4RST) en 2002 / Assessment of

Greenland halibut (*Reinhardtius hippoglossoides*) in the Gulf of St. Lawrence (4RST) in 2002. DFO Can. Sci. Adv. Sec. Res. Doc. 2003/088: 72 p.

Morin, B., Power, D. and Gagnon, P. 1994. Distribution of redfish (*Sebastes spp.*) in the Gulf of St. Lawrence and in the Laurentian Channel based on RV surveys and commercial fishery catch rates. DFO Atl. Fish. Res. Doc. 94/91: 52 p.

Morin, R., and Hurlbut, T. 1994. Distribution of witch (*Glyptocephalus cynoglossus* L.) and white hake (*Urophycis tenuis*) in the Gulf of St. Lawrence in relation to management units. DFO Atl. Fish. Res. Doc. 94/90: 30 p.

Powles, P.M. 1965. Life history and ecology of American plaice (*Hippoglossoides platessoides* F.) in the Magdalen Shallows. J. Fish. Res. Board Can. 22: 565-598.

Scott, W.G., and Scott, M.B. 1988. Atlantic fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219: 731 p.

Sévigny, J-M., Gagné, P., de Lafontaine, Y., and Dodson, J. 2000. Identification and distribution of larvae of redfish (*Sebastes fasciatus* and *S. mentella*, Sorpaenidae) in the Gulf of St. Lawrence. Fish. Bull. 98: 375-388.

Simon, J.E., Frank, K.T., and Kulka, D. W. 2002. Distribution and abundance of barndoor skate *Dipturus laevis* in the Canadian Atlantic based upon research vessel surveys and industry/science surveys. DFO Can. Sci. Adv. Sec. Res. Doc. 2002/070: 67 p.

Simpson, M.R., and Kulka, D.W. 2001. Distribution and biomass of selected unregulated species occurring in the NAFO regulatory area and adjacent areas. NAFO SCR Doc. 01/162: 79 p.

Sinclair, A., and Currie, L. 1994. Timing of cod migrations into and out of the Gulf of St. Lawrence based on commercial fisheries, 1986-93. DFO Atl. Fish. Res. Doc. 94/47: 18 p.

Sinclair, A., Chouinard, G.A., Swain, D., Hébert, R., Nielsen, G., Hanson, M., Currie, L., and Hurlbut, T. 1994. Assessment of the fishery for southern Gulf of St. Lawrence cod: May 1994. DFO Atlantic Fisheries Res. Doc. 94/77: 116 p.

St-Pierre, J.-F., and de Lafontaine,Y. 1995. Fecundity and reproduction characteristics of beaked redfish (*Sebastes fasciatus* and *S. mentella*) in the Gulf of St. Lawrence. Can. Tech. Rep. Fish. Aquat. Sci. 2059: vii + 32 p.

Swain, D.P., and Poirier, G.A. 2001. Status of witch flounder in NAFO Divisions 4RST, February 2001. DFO Can. Stock Assess. Sec. Res. Doc. 2001/021: 55 p.

Swain, D.P., Frank, K.T., and Maillet, G. 2001. Delineating stocks of Atlantic cod (*Gadus morhua*) in the Gulf of St. Lawrence and Cabot Strait areas using vertebral number. ICES J. Mar. Sci. 58: 253-269.

Swain, D.P., Hurlbut, T., and Benoît, H.P. 2005. Changes in the abundance and size of skates in the southern Gulf of St. Lawrence, 1971-2002. J. Northw. Atl. Fish.Sci. 36: 1-12.

Swain, D.P., Chouinard, G.A., Morin, R., and Drinkwater, K.F. 1998. Seasonal variation in the habitat associations of Atlantic cod (*Gadus morhua*) and American place (*Hippoglossoides platessoides*) from the southern Gulf of St. Lawrence. Can. J. Fish. Aquat. Sci. 55: 2548-2561.

Templeman, W. 1962. Divisions of cod stocks in the Northwest Atlantic. ICNAF Redbook III: 79-123.

Templeman, W. 1963. Distribution of sharks in the Canadian Atlantic. Bull. Fish. Res. Bd. Canada 140: vii + 77 p.

Templeman, W. 1974. Migrations and intermingling of Atlantic cod (*Gadus morhua*) stocks of the Newfoundland area. J. Fish. Res. Bd. Can. 31: 1073-1092.

Templeman, W. 1984. Migrations of spiny dogfish, *Squalus acanthias*, and recapture success from tagging in the Newfoundland area 1963-65. J. Northw. Atl. Fish. Sci. 5: 47-53.

Templeman, W., and Fleming, A.M. 1962. Cod tagging in the Newfoundland area during 1947 and 1948. J. Fish. Res. Bd. Can. 19: 445-487.

Warren, W.G. 1997. Report on the comparative fishing trial between the Gadus Atlantica and Teleost. NAFO Sci. Counc. Stud. no. 29, pp. 8.

Winters, G.H., and Beckett, J.S. 1974. Migrations, biomass and stock interrelationships of southwest Newfoundland–southern Gulf herring from mark-recapture experiments. ICNAF Res. Bull. 13:67-79.

Table 1. Summary of sampling details for the surveys conducted in the Cabot Strait during January, 1994-1997.

	Year			
	1994	1995	1996	1997
Research vessel	C.C.G.S. *Alfred Needler*	C.C.G.S. *Alfred Needler*	C.C.G.S. *Wilfred Templeman*	C.C.G.S. *Wilfred Templeman*
Mission #	N197	N214	T182	T201
Survey trawl	Atlantic Western IIA	Atlantic Western IIA	Campelen 1800	Campelen 1800
Survey dates	Jan. 14 - 24	Jan. 11 - 28	Jan. 6 - 22	Jan. 6 - 26
Survey design	Stratified Random	Grid or Lattice	Grid or Lattice	Grid or Lattice
# of stations sampled	70	164	138	104
# of day sets (07:40 - 16:39 hrs.)	26	59	50	37
# of night sets (16:40 - 07:39 hrs.)	44	105	88	67
Range of depths (m) of sampled stations	56 - 515	64 - 536	37 - 529	64 - 523
Range of tow distances (nm) at sampled stations	1.2 - 2.1	1.2 - 1.9	0.4 - 1.0	0.5 - 1.0

Table 2: Relative occurrence of marine fish species caught in Cabot Strait during January, 1994 to 1997. Relative occurrence is expressed as proportion of sampled stations where the species / species group was captured. The number of survey stations by year are summarized in Table 1.

Species – Common Name	Scientific name	1994 Prop. of stations (N = 70)	1995 Prop. of stations (N = 164)	1996 Prop. of stations (N =138)	1997 Prop. of stations (N = 104)
Atlantic cod	*Gadus morhua*	0.871	0.854	0.949	0.981
Haddock	*Melanogrammus aeglefinus*	0.043	0.043	0.036	0.029
White hake	*Urophycis tenuis*	0.514	0.622	0.710	0.750
Silver hake	*Merluccius bilinearis*	0.071	0.085	0.022	0.038
Pollock	*Pollachius virens*	0.114	0.366	0.406	0.260
Redfish	*Sebastes sp.*	0.857	0.860	0.978	0.981
Atlantic halibut	*Hippoglossus hippoglossus*	0.143	0.122	0.029	0.077
Greenland halibut	*Reinhardtius hippoglossoides*	0.571	0.598	0.681	0.731
Black swallower	*Chiasmodon niger*	0.000	0.000	0.000	0.010
American plaice	*Hippoglossoides platessoides*	0.886	0.866	0.949	0.952
Witch flounder	*Glyptocephalus cynoglossus*	0.671	0.689	0.783	0.856
Yellowtail flounder	*Limanda ferruginea*	0.029	0.043	0.058	0.067
Winter flounder	*Pseudopleuronectes americanus*	0.014	0.012	0.022	0.019
Atlantic wolffish	*Anarhichas lupus*	0.157	0.159	0.210	0.231
Spotted wolffish	*Anarhichas minor*	0.000	0.012	0.022	0.019
Northern wolffish	*Anarhichas denticulatus*	0.029	0.018	0.058	0.010
Atlantic herring	*Clupea harengus*	0.429	0.311	0.471	0.433
Gaspereau	*Alosa pseudoharengus*	0.029	0.006	0.072	0.058
Rainbow smelt	*Osmerus mordax*	0.029	0.000	0.000	0.000
Capelin	*Mallotus villosus*	0.257	0.335	0.399	0.856
Greenland manefish	*Caristius groenlandicus*	0.000	0.000	0.007	0.000
Arctic cod	*Boreogadus saida*	0.000	0.006	0.094	0.067
Spotted hake	*Urophycis regia*	0.000	0.000	0.007	0.000
Longfin hake	*Urophycis chesteri*	0.529	0.549	0.696	0.654
Fourbeard rockling	*Enchelyopus cimbrius*	0.286	0.226	0.442	0.490
Threebeard rockling	*Gaidropsarus ensis*	0.014	0.000	0.007	0.019
Greenland cod	*Gadus ogac*	0.000	0.006	0.000	0.000
Brill (Windowpane)	*Scophthalmus aquosus*	0.100	0.049	0.065	0.058
Lanternfish unspecified	*Myctophidae (sp.)*	0.114	0.171	0.464	0.394
Boa dragonfish	*Stomias boa ferox*	0.000	0.000	0.130	0.058
Atlantic argentine	*Argentina silus*	0.014	0.012	0.080	0.144
Round herring	*Etrumeus teres*	0.000	0.006	0.000	0.000
Sloan's viperfish	*Chauliodus sloani*	0.000	0.000	0.101	0.019
Barndoor skate	*Dipturus laevis*	0.000	0.000	0.014	0.019
Thorny skate	*Amblyraja radiata*	0.843	0.744	0.797	0.894
Smooth skate	*Malacoraja senta*	0.571	0.445	0.659	0.644
Winter skate	*Leucoraja ocellata*	0.114	0.146	0.116	0.202
Spinytail skate	*Bathyraja spinicauda*	0.000	0.006	0.000	0.029
Round skate	*Rajella fyllae*	0.000	0.000	0.007	0.019
Spiny dogfish	*Squalus acanthias*	0.014	0.067	0.051	0.010
Black dogfish	*Centroscyllium fabricii*	0.457	0.500	0.601	0.587
Greenland shark	*Somniosus microcephalus*	0.014	0.000	0.000	0.000
Sea lamprey	*Petromyzon marinus*	0.000	0.006	0.007	0.029
Atlantic hagfish	*Myxine glutinosa*	0.314	0.421	0.688	0.740
Longhorn sculpin	*Myoxocephalus octodecemspinosus*	0.071	0.110	0.181	0.212
Shorthorn sculpin	*Myoxocephalus scorpius*	0.000	0.000	0.022	0.038

Table 2: (Continued).

Species – Common Name	Scientific name	1994	1995	1996	1997
		Prop. of stations (N = 70)	Prop. of stations (N = 164)	Prop. of stations (N =138)	Prop. of stations (N = 104)
Moustache sculpin (Mailed sculpin)	*Triglops murrayi*	0.157	0.152	0.304	0.269
Arctic hookear sculpin	*Artediellus uncinatus*	0.171	0.348	0.341	0.365
Polar sculpin	*Cottunculus microps*	0.043	0.055	0.094	0.096
Spatulate sculpin	*Icelus spatula*	0.000	0.000	0.014	0.010
Arctic sculpin	*Myoxocephalus scorpioides*	0.000	0.000	0.022	0.000
Sea raven	*Hemitripterus americanus*	0.129	0.140	0.232	0.221
Aligatorfish	*Aspidophoroides monopterygius*	0.071	0.152	0.246	0.154
Atlantic poacher	*Leptagonus decagonus*	0.043	0.110	0.043	0.144
Threespine stickleback	*Gasterosteus aculeatus*	0.014	0.043	0.036	0.260
Myctophum sp.	Myctophum sp.	0.000	0.000	0.007	0.000
Angler (Monkfish or Goosefish)	*Lophius americanus*	0.100	0.055	0.065	0.231
Lesser deepsea angler	*Cryptopsaras couesi*	0.000	0.000	0.007	0.010
Common grenadier (Marlin-spike)	*Nezumia bairdii*	0.557	0.555	0.790	0.808
Seasnail unspecified	*Liparis (sp.)*	0.000	0.049	0.130	0.010
Lumpfish	*Cyclopterus lumpus*	0.143	0.250	0.246	0.221
Atlantic spiny lumpsucker	*Eumicrotremus spinosus*	0.114	0.116	0.159	0.183
Atlantic seasnail	*Liparis atlanticus*	0.014	0.024	0.043	0.000
Striped seasnail	*Liparis liparis*	0.000	0.018	0.087	0.038
Gelatinous seasnail	*Liparis fabricii*	0.086	0.091	0.333	0.202
Inquiline seasnail	*Liparis inquilinus*	0.000	0.000	0.014	0.000
Blacksnout seasnail	*Paraliparis copei*	0.000	0.030	0.000	0.365
Varigated snailfish (Polka-dot snailfish)	*Liparis gibbus*	0.043	0.055	0.065	0.106
Northern cutthroat eel	*Synaphobranchus kaupii*	0.000	0.000	0.014	0.000
Wolf eelpout	*Lycenchelys verrillii*	0.000	0.000	0.022	0.038
Atlantic snipe eel	*Nemichthys scolopaceus*	0.000	0.000	0.029	0.000
Margined snake eel	*Ophichthus cruentifer*	0.000	0.000	0.000	0.000
Sawtooth eel (Stout sawpalate)	*Serrivomer beanii*	0.000	0.000	0.036	0.000
Fish doctor	*Gymnelus viridis*	0.000	0.000	0.022	0.000
Common wolf eel	*Lycenchelys paxillus*	0.000	0.030	0.210	0.144
Atlantic eelpout	*Lycodes terraenovae*	0.000	0.000	0.000	0.019
Laval's eelpout	*Lycodes lavalaei*	0.100	0.085	0.058	0.135
Snakeblenny	*Lumpenus lampretaeformis*	0.029	0.024	0.000	0.029
Daubed shanny	*Leptoclinus maculatus*	0.057	0.165	0.152	0.144
Fourline snakeblenny	*Eumesogrammus praecisus*	0.014	0.055	0.051	0.067
Wrymouth	*Cryptacanthodes maculatus*	0.057	0.024	0.029	0.000
Ocean pout	*Zoarces americanus*	0.000	0.000	0.000	0.010
Eelpout unspecified	*Lycodes (sp.)*	0.000	0.000	0.000	0.010
Esmark's eelpout	*Lycodes esmarki*	0.043	0.018	0.072	0.106
Atlantic soft pout	*Melanostigma atlanticum*	0.143	0.329	0.428	0.510
Vahl's eelpout	*Lycodes vahlii*	0.114	0.195	0.167	0.192
Barracudina	*Paralepis (sp.)*	0.000	0.000	0.000	0.000
Atlantic silver hatchetfish	*Argyropelecus aculeatus*	0.000	0.000	0.007	0.029
White barracudina	*Arctozenus risso*	0.014	0.232	0.688	0.798
Barracudina unspecified	*Paralepididae F.*	0.000	0.000	0.007	0.000
Daggertooth	*Anotopterus pharao*	0.000	0.000	0.000	0.010
Snubnosed spiny eel	*Notacanthus chemnitzii*	0.000	0.000	0.029	0.010
Dragonfish unspecified	*Stomias (sp.)*	0.000	0.000	0.014	0.000
Lowfin snailfish	*Paraliparis calidus*	0.000	0.000	0.000	0.029

Table 3: Summary of marine fish species catches in Cabot Strait during the January surveys conducted from 1994 to 1997. Numbers and weights are adjusted to a standard tow for each vessel and adjusted for diel differences where necessary.

Species – Common Name	Scientific name	1994		1995		1996		1997	
		numbers	kg	numbers	kg	numbers	kg	numbers	kg
Atlantic cod	*Gadus morhua*	7434	3924.91	15005	8244.38	13793	7602.16	20467	11078.53
Haddock	*Melanogrammus aeglefinus*	4	6.61	8	6.16	9	19.23	6	4.08
White hake	*Urophycis tenuis*	1287	496.29	2526	647.70	2305	752.50	2461	614.75
Silver hake	*Merluccius bilinearis*	11	1.30	32	3.27	8	1.87	4	0.24
Pollock	*Pollachius virens*	9	15.22	1933	184.49	236	138.92	108	71.08
Redfish	*Sebastes sp.*	3600	1001.13	8248	3363.21	16591	5855.56	17303	4706.88
Atlantic halibut	*Hippoglossus hippoglossus*	13	101.74	31	139.25	4	29.43	10	12.88
Greenland halibut	*Reinhardtius hippoglossoides*	596	383.03	1902	1099.72	1681	1162.07	2098	1364.95
Black swallower	*Chiasmodon niger*							2	0.08
American plaice	*Hippoglossoides platessoides*	3958	929.78	4491	902.15	5253	982.15	7186	1210.25
Witch flounder	*Glyptocephalus cynoglossus*	1917	496.69	2369	540.85	5237	799.68	4826	710.06
Yellowtail flounder	*Limanda ferruginea*	5	1.31	10	2.01	281	16.13	19	3.18
Winter flounder	*Pseudopleuronectes americanus*	1	0.44	2	0.02	9	2.16	2	0.47
Atlantic wolffish	*Anarhichas lupus*	42	12.28	77	30.53	306	38.73	364	27.33
Spotted wolffish	*Anarhichas minor*			2	0.98	3	2.38	2	0.07
Northern wolffish	*Anarhichas denticulatus*	2	2.69	3	2.98	10	6.85	1	12.50
Atlantic herring	*Clupea harengus*	1009	208.55	3985	935.17	5690	748.99	18924	3405.58
Gaspereau	*Alosa pseudoharengus*	3	0.02	1	0.03	13	0.22	7	0.07
Rainbow smelt	*Osmerus mordax*	17	0.31						
Capelin	*Mallotus villosus*	243	3.05	26721	206.96	854	10.81	7071	89.38
Greenland manefish	*Caristius groenlandicus*					1	0.10		
Arctic cod	*Boreogadus saida*			2	0.00	230	1.19	18	0.30
Spotted hake	*Urophycis regia*					3	0.27		
Longfin hake	*Urophycis chesteri*	817	49.56	1827	155.30	5942	449.17	5571	367.67
Fourbeard rockling	*Enchelyopus cimbrius*	38	1.42	48	10.47	145	6.66	134	6.27
Threebeard rockling	*Gaidropsarus ensis*	1	0.02			1	0.01	3	0.26
Greenland cod	*Gadus ogac*			1	1.03				
Brill (Windowpane)	*Scophthalmus aquosus*	14	2.37	14	2.67	30	4.61	18	1.32
Lanternfish unspecified	*Myctophidae (sp.)*	13	0.08	155	0.86	1506	6.65	316	5.41
Boa dragonfish	*Stomias boa ferox*					25	0.54	8	0.14
Atlantic argentine	*Argentina silus*	1	0.32	3	1.18	126	51.43	192	96.75
Round herring	*Etrumeus teres*			1	0.28				
Sloan's viperfish	*Chauliodus sloani*					14	0.41	2	0.03
Barndoor skate	*Dipturus laevis*					2	23.15	2	20.18
Thorny skate	*Amblyraja radiata*	1033	424.72	1109	459.24	1294	686.85	815	496.26
Smooth skate	*Malacoraja senta*	183	55.62	206	50.36	438	163.61	374	106.06
Winter skate	*Leucoraja ocellata*	482	492.77	75	114.77	44	36.55	67	97.63
Spinytail skate	*Bathyraja spinicauda*			2	0.82			4	1.80
Round skate	*Rajella fyllae*					2	0.41	3	0.78
Spiny dogfish	*Squalus acanthias*	1	2.33	53	112.03	14	24.11	1	1.73
Black dogfish	*Centroscyllium fabricii*	2038	779.43	5378	2704.65	17111	3483.92	9770	2221.68
Greenland shark	*Somniosus microcephalus*	1	1458.33						
Sea lamprey	*Petromyzon marinus*			1	0.01	1	0.01	5	0.05
Atlantic hagfish	*Myxine glutinosa*	40	7.99	194	16.52	593	37.00	1050	54.63
Longhorn sculpin	*Myoxocephalus octodecemspinosus*	8	1.76	36	10.88	463	59.65	72	11.41
Shorthorn sculpin	*Myoxocephalus scorpius*					5	2.68	3	2.48

Table 3: (Continued).

Species – Common Name	Scientific name	1994		1995		1996		1997	
		numbers	kg	numbers	kg	numbers	kg	numbers	kg
Moustache sculpin (Mailed sculpin)	*Triglops murrayi*	33	0.32	108	0.88	674	7.18	417	5.03
Arctic hookear sculpin	*Artediellus uncinatus*	28	0.15	282	0.92	301	1.61	267	1.21
Polar sculpin	*Cottunculus microps*	4	0.27	9	0.18	49	0.41	44	0.33
Spatulate sculpin	*Icelus spatula*					8	0.02	1	0.00
Arctic sculpin	*Myoxocephalus scorpioides*					3	0.03		
Sea raven	*Hemitripterus americanus*	11	7.61	66	55.52	61	44.05	54	41.54
Aligatorfish	*Aspidophoroides monopterygius*	7	0.03	73	0.31	114	0.71	60	0.33
Atlantic poacher	*Leptagonus decagonus*	6	0.16	36	1.22	29	0.74	67	0.87
Threespine stickleback	*Gasterosteus aculeatus*	1	0.04	6	0.03	11	0.04	47	0.26
Myctophum sp.	Myctophum sp.					1	0.01		
Angler (Monkfish or Goosefish)	*Lophius americanus*	8	35.03	9	22.75	11	8.16	32	25.17
Lesser deepsea angler	*Cryptopsaras couesi*					2	0.19	2	0.10
Common grenadier (Marlin-spike)	*Nezumia bairdii*	981	50.43	3917	197.47	11262	559.32	9026	403.34
Seasnail unspecified	*Liparis (sp.)*			11	0.11	39	0.47	1	0.01
Lumpfish	*Cyclopterus lumpus*	26	76.11	226	326.96	119	249.41	99	231.01
Atlantic spiny lumpsucker	*Eumicrotremus spinosus*	17	0.24	48	0.76	174	1.91	259	2.58
Atlantic seasnail	*Liparis atlanticus*	1	0.00	6	0.02	8	0.91		
Striped seasnail	*Liparis liparis*			6	0.56	43	1.48	8	0.06
Gelatinous seasnail	*Liparis fabricii*	7	0.20	19	0.20	145	2.16	55	0.64
Inquiline seasnail	*Liparis inquilinus*					4	0.26		
Blacksnout seasnail	*Paraliparis copei*			10	0.15			158	2.33
Varigated snailfish (Polka-dot snailfish)	*Liparis gibbus*	3	0.10	23	0.58	60	0.48	35	0.82
Northern cutthroat eel	*Synaphobranchus kaupii*					2	0.03		
Wolf eelpout	*Lycenchelys verrillii*					5	0.03	8	0.30
Atlantic snipe eel	*Nemichthys scolopaceus*					5	0.05		
Margined snake eel	*Ophichthus cruentifer*			96	0.92			20	0.02
Sawtooth eel (Stout sawpalate)	*Serrivomer beanii*					7	0.71		
Fish doctor	*Gymnelus viridis*					3	0.04		
Common wolf eel	*Lycenchelys paxillus*			6	0.50	44	1.67	27	0.42
Atlantic eelpout	*Lycodes terraenovae*							2	0.26
Laval's eelpout	*Lycodes lavalaei*	18	1.71	40	6.18	54	5.34	64	3.40
Snakeblenny	*Lumpenus lampretaeformis*	3	0.02	4	0.04			7	0.09
Daubed shanny	*Leptoclinus maculatus*	9	0.23	148	0.80	158	0.84	108	0.49
Fourline snakeblenny	*Eumesogrammus praecisus*	1	0.03	29	1.51	60	2.49	55	1.85
Wrymouth	*Cryptacanthodes maculatus*	9	1.63	4	0.54	4	0.19		
Ocean pout	*Zoarces americanus*							3	1.02
Eelpout unspecified	*Lycodes (sp.)*							4	0.11
Esmark's eelpout	*Lycodes esmarki*	3	0.72	3	0.97	10	0.95	15	1.93
Atlantic soft pout	*Melanostigma atlanticum*	24	0.07	173	0.99	355	2.04	332	1.27
Vahl's eelpout	*Lycodes vahlii*	19	2.26	79	5.36	78	5.68	121	4.95
Barracudina	*Paralepis (sp.)*	6	0.09						
Atlantic silver hatchetfish	*Argyropelecus aculeatus*					1	0.01	5	0.02
White barracudina	*Arctozenus risso*	1	0.01	66	0.90	1055	14.41	892	13.83
Barracudina unspecified	*Paralepididae F.*					44	0.49		
Daggertooth	*Anotopterus pharao*							1	0.02
Snubnosed spiny eel	*Notacanthus chemnitzii*					5	4.92	2	1.82
Dragonfish unspecified	*Stomias (sp.)*					2	0.01		
Lowfin snailfish	*Paraliparis calidus*							7	0.09

Table 4: Diel differences in relative catchability (day relative to night – $\beta 2_1$) for the 25 most abundant fish species caught in Cabot Strait during the January surveys conducted by CCGS *Alfred Needler* (AN) in 1994 and 1995 and by CCGS *Wilfred Templeman* (WT) in 1996 and 1997. The standard error (S.E.) and significance level (p) were derived from the randomization procedure. The number of observations (n; day and night), the number of non-zero catches (non-zero) and the factor (k =(exp($\beta 2_1$)) used to adjust night catches to day equivalents are given.

Common name	Scientific name	Vessel	$\beta 2_1$	S.E.	n	non-zero	p	k
Atlantic cod	*Gadus morhua*	AN	0.617	0.512	207	175	0.185	
		WT	-0.035	0.416	219	210	0.925	
White hake	*Urophycis tenuis*	AN	0.113	0.293	186	127	0.678	
		WT	0.026	0.290	219	163	0.910	
Pollock	*Pollachius virens*	AN	-0.891	0.647	171	61	0.202	
		WT	0.477	0.458	206	77	0.263	
Redfish	*Sebastes sp.*	AN	0.613	0.362	214	186	0.055	
		WT	-0.036	0.190	219	215	0.822	
Atlantic halibut	*Hippoglossus hippoglossus*	AN	0.051	0.473	136	27	0.887	
		WT	-0.281	2.444	124	9	0.699	
Greenland halibut	*Reinhardtius hippoglossoides*	AN	0.195	0.319	212	124	0.536	
		WT	0.146	0.181	206	155	0.409	
American plaice	*Hippoglossoides platessoides*	AN	-0.244	0.227	211	183	0.262	
		WT	0.023	0.247	219	207	0.923	
Witch flounder	*Glyptocephalus cynoglossus*	AN	0.050	0.200	212	147	0.782	
		WT	0.117	0.161	219	180	0.435	
Atlantic wolffish	*Anarhichas lupus*	AN	-0.927	0.500	110	34	0.079	
		WT	-1.435	0.502	164	46	0.011	0.238
Atlantic herring	*Clupea harengus*	AN	-0.860	0.882	178	70	0.386	
		WT	-0.099	0.790	214	97	0.915	
Capelin	*Mallotus villosus*	AN	-0.236	1.214	171	63	0.828	
		WT	-0.608	0.424	220	122	0.136	
Longfin hake	*Phycis chesteri*	AN	-0.102	0.171	175	116	0.534	
		WT	0.234	0.185	197	150	0.190	
Atlantic argentine	*Argentina silus*	AN	-25.126	21.119	15	1	0.631	
		WT	-0.320	1.116	87	23	0.644	
Barndoor skate	*Dipturus laevis*	AN	no data					
		WT	-25.451	23.845	34	1	0.633	
Thorny skate	*Amblyraja radiata*	AN	-0.531	0.269	214	162	0.043	0.588
		WT	-0.273	0.194	219	179	0.145	
Smooth skate	*Malacoraja senta*	AN	-0.436	0.273	206	99	0.113	
		WT	-0.495	0.236	217	146	0.034	0.610
Winter skate	*Leucoraja ocellata*	AN	-0.362	0.949	126	24	0.723	
		WT	-0.750	0.624	202	28	0.227	
Spiny dogfish	*Squalus acanthias*	AN	-1.739	5.428	63	6	0.137	
		WT	0.025	10.182	74	6	0.989	
Black dogfish	*Centroscyllium fabricii*	AN	0.187	0.177	145	106	0.297	
		WT	0.062	0.272	201	133	0.837	
Atlantic hagfish	*Myxine glutinosa*	AN	-0.141	0.229	186	82	0.505	
		WT	0.008	0.194	208	160	0.968	
Longhorn sculpin	*Myoxocephalus octodecemspinosus*	AN	0.088	2.333	90	14	0.885	
		WT	0.051	0.496	178	32	0.916	
Sea raven	*Hemitripterus americanus*	AN	-0.267	0.675	164	25	0.683	
		WT	-0.061	0.372	215	46	0.845	
Angler / Monkfish	*Lophius americanus*	AN	-0.046	0.691	91	11	0.949	
		WT	-0.711	0.437	138	27	0.115	
Common grenadier	*Nezumia bairdii*	AN	0.052	0.144	175	119	0.695	
		WT	0.108	0.151	207	176	0.446	
Lumpfish	*Cyclopterus lumpus*	AN	1.484	0.430	165	46	0.001	4.410
		WT	0.908	0.524	199	53	0.046	2.480

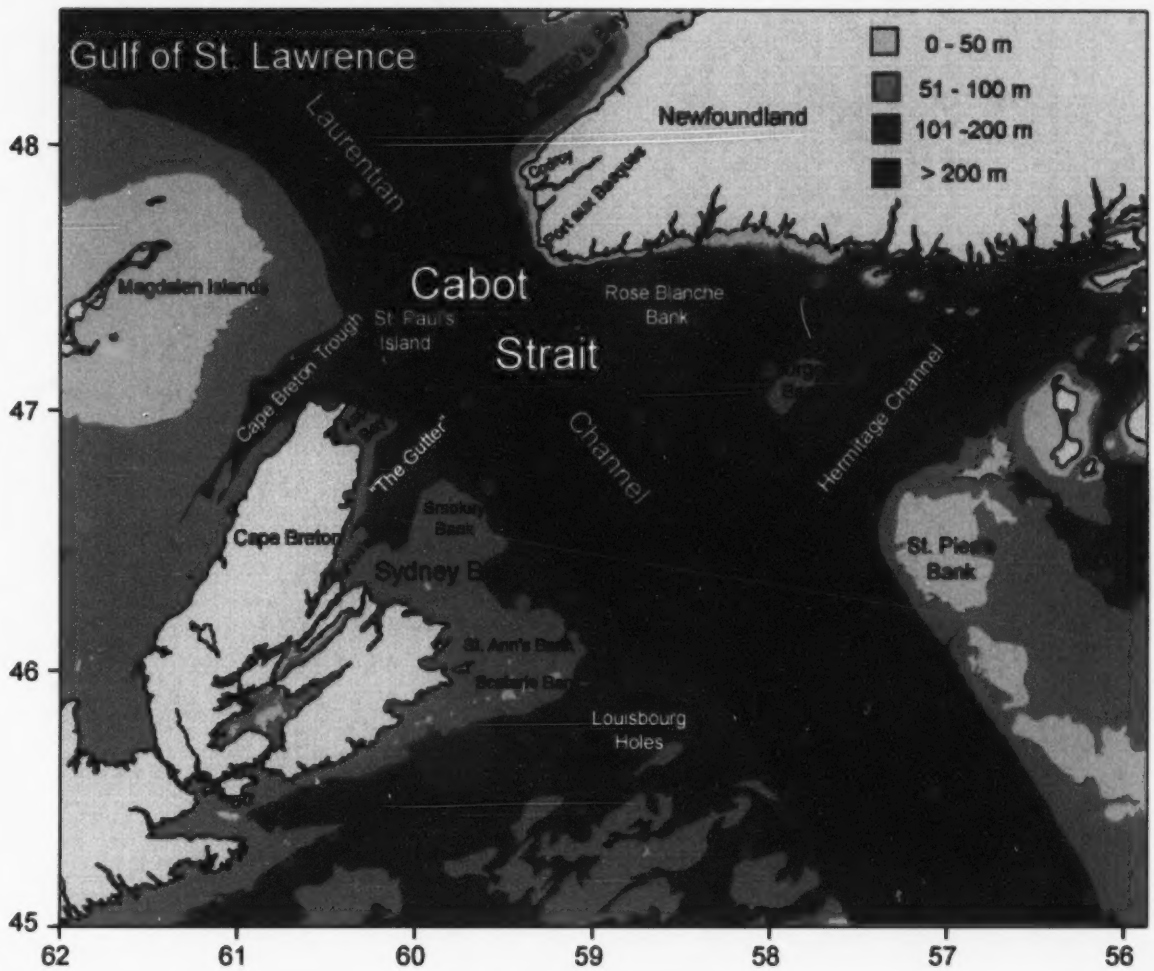

Figure 1: Bathymetric chart of the Cabot Strait showing place names mentioned in the text.

Table 4: Diel differences in relative catchability (day relative to night – $\beta 2_1$) for the 25 most abundant fish species caught in Cabot Strait during the January surveys conducted by CCGS *Alfred Needler* (AN) in 1994 and 1995 and by CCGS *Wilfred Templeman* (WT) in 1996 and 1997. The standard error (S.E.) and significance level (*p*) were derived from the randomization procedure. The number of observations (*n*; day and night), the number of non-zero catches (non-zero) and the factor (k =(exp($\beta 2_1$)) used to adjust night catches to day equivalents are given.

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		WT	-0.036	0.190	219	215	0.822	
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		WT	0.146	0.181	206	155	0.409	
American plaice	*Hippoglossoides platessoides*	AN	-0.244	0.227	211	183	0.262	
		WT	0.023	0.247	219	207	0.923	
Witch flounder	*Glyptocephalus cynoglossus*	AN	0.050	0.200	212	147	0.782	
		WT	0.117	0.161	219	180	0.435	
Atlantic wolffish	*Anarhichas lupus*	AN	-0.927	0.500	110	34	0.079	
		WT	-1.435	0.502	164	46	0.011	0.238
Atlantic herring	*Clupea harengus*	AN	-0.860	0.882	178	70	0.386	
		WT	-0.099	0.790	214	97	0.915	
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		WT	-0.320	1.116	87	23	0.644	
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		WT	-25.451	23.845	34	1	0.633	
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Winter skate	*Leucoraja ocellata*	AN	-0.362	0.949	126	24	0.723	
		WT	-0.750	0.624	202	28	0.227	
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		WT	0.025	10.182	74	6	0.989	
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		WT	0.062	0.272	201	133	0.837	
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Longhorn sculpin	*Myoxocephalus octodecemspinosus*	AN	0.088	2.333	90	14	0.885	
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Sea raven	*Hemitripterus americanus*	AN	-0.267	0.675	164	25	0.683	
		WT	-0.061	0.372	215	46	0.845	
Angler / Monkfish	*Lophius americanus*	AN	-0.046	0.691	91	11	0.949	
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		WT	0.108	0.151	207	176	0.446	
Lumpfish	*Cyclopterus lumpus*	AN	1.484	0.430	165	46	0.001	4.410
		WT	0.908	0.524	199	53	0.046	2.480

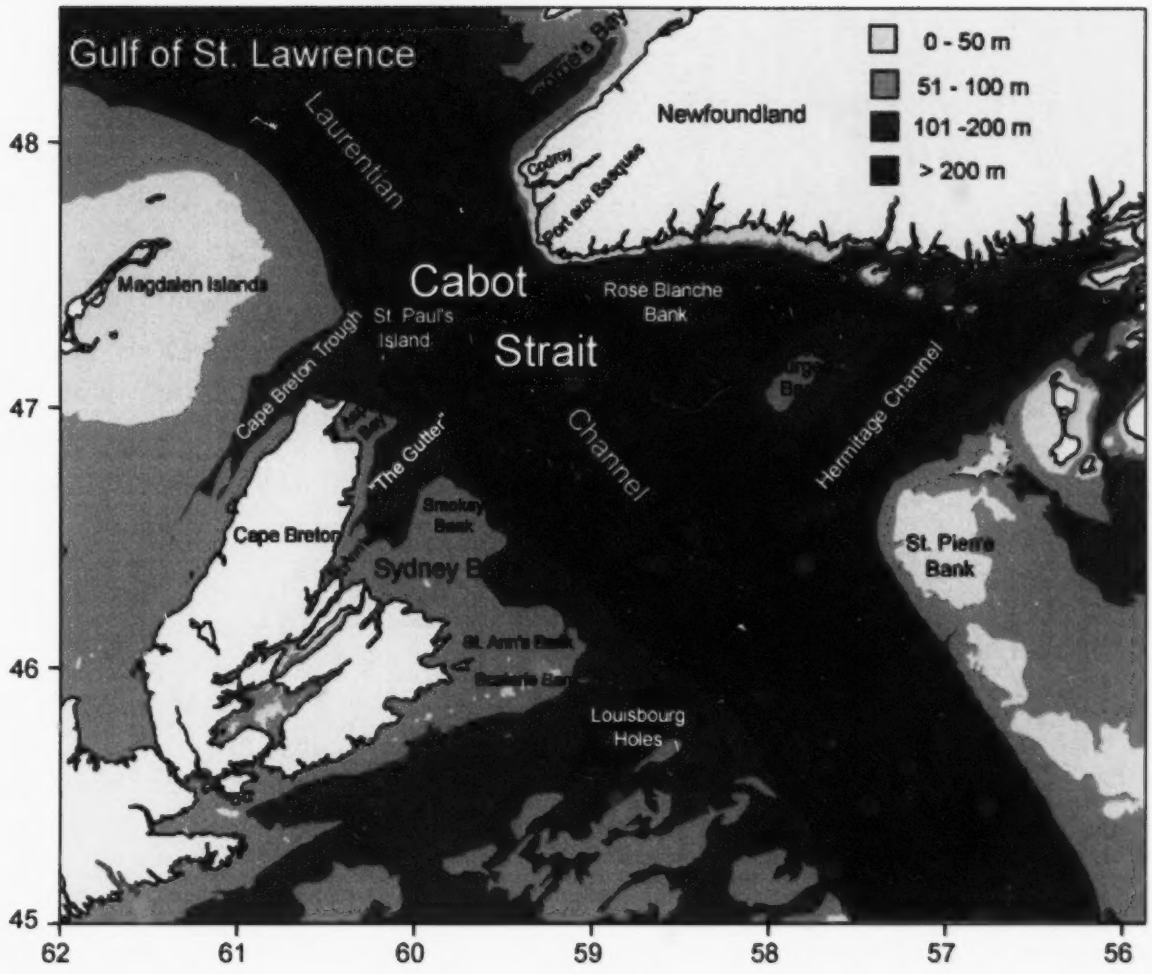

Figure 1: Bathymetric chart of the Cabot Strait showing place names mentioned in the text.

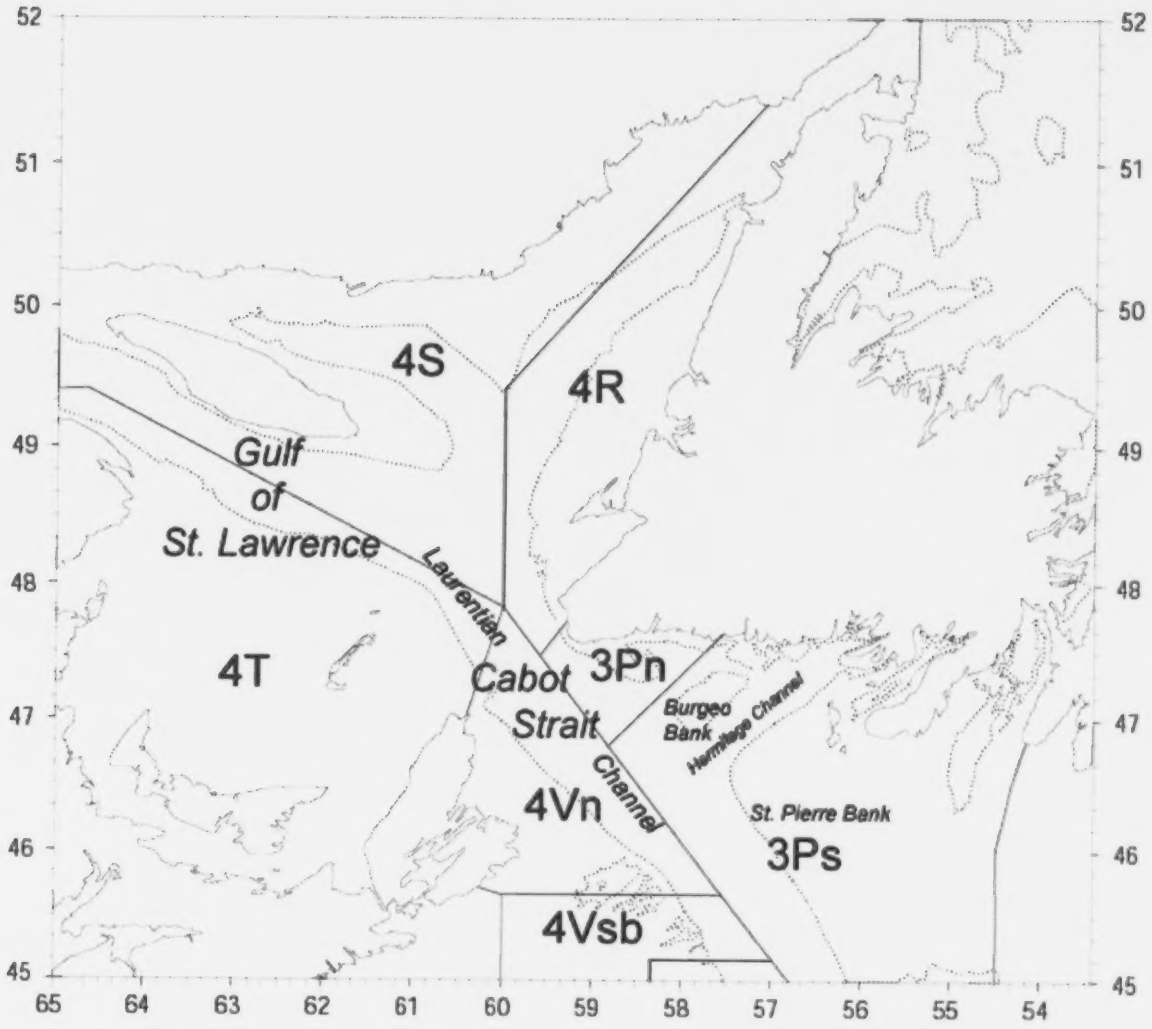

Figure 2: Chart of the Gulf of St. Lawrence and Cabot Strait showing divisions and unit areas of the Northwest Atlantic Fisheries Organization mentioned in the text.

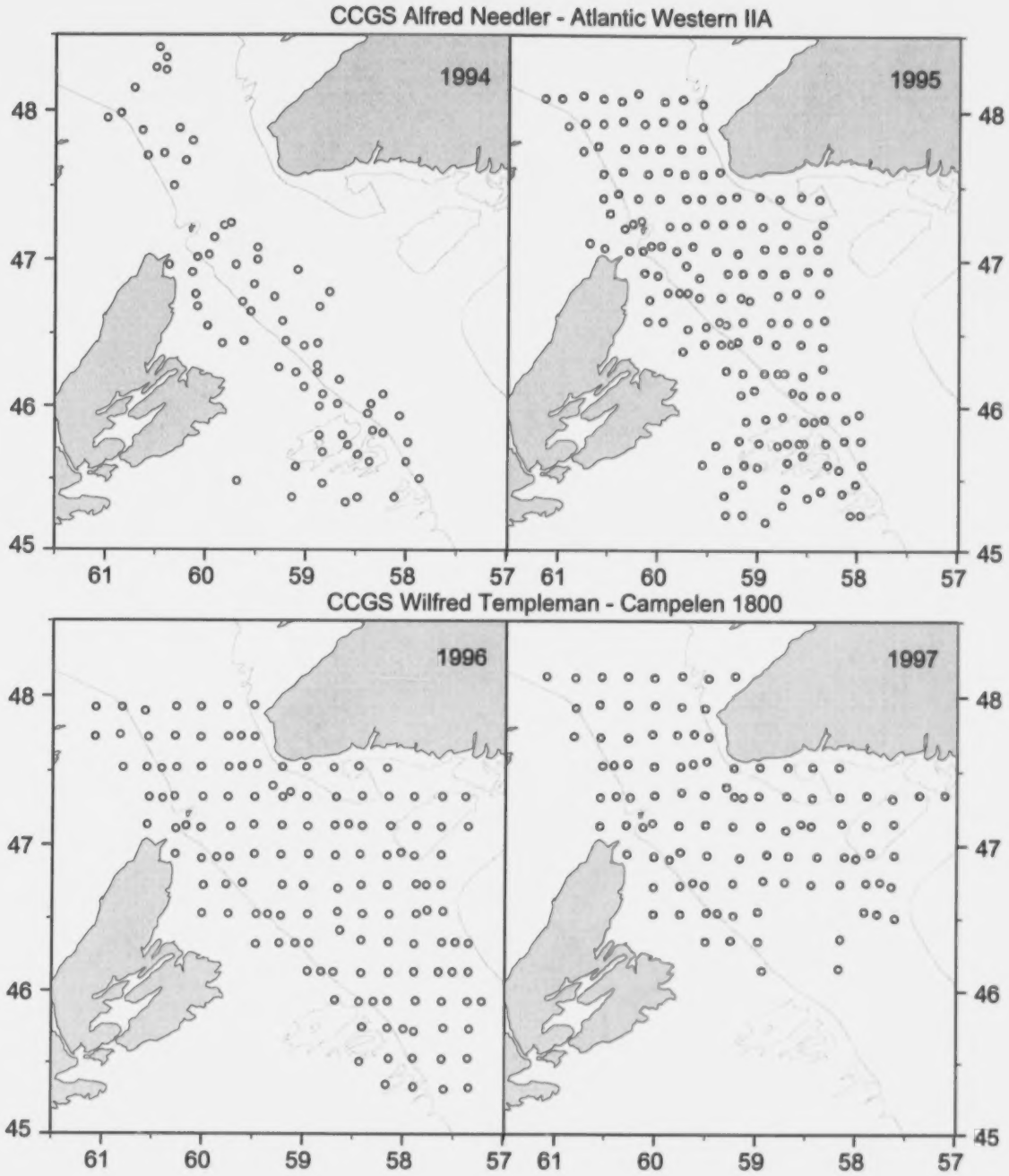

Figure 3: Location of sampling stations during January surveys conducted in Cabot Strait, 1994 –1997.

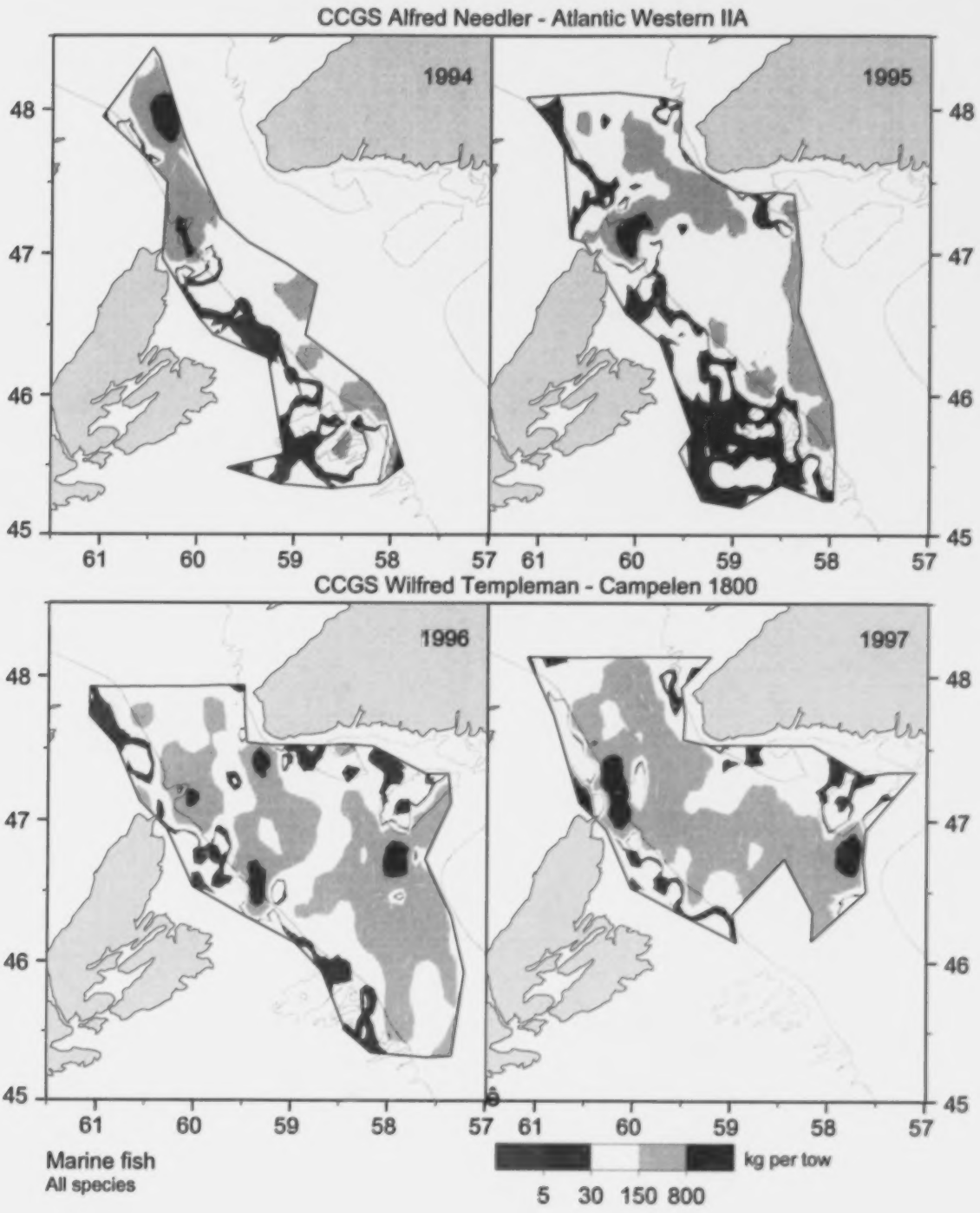

Figure 4: Distribution of marine fish species catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

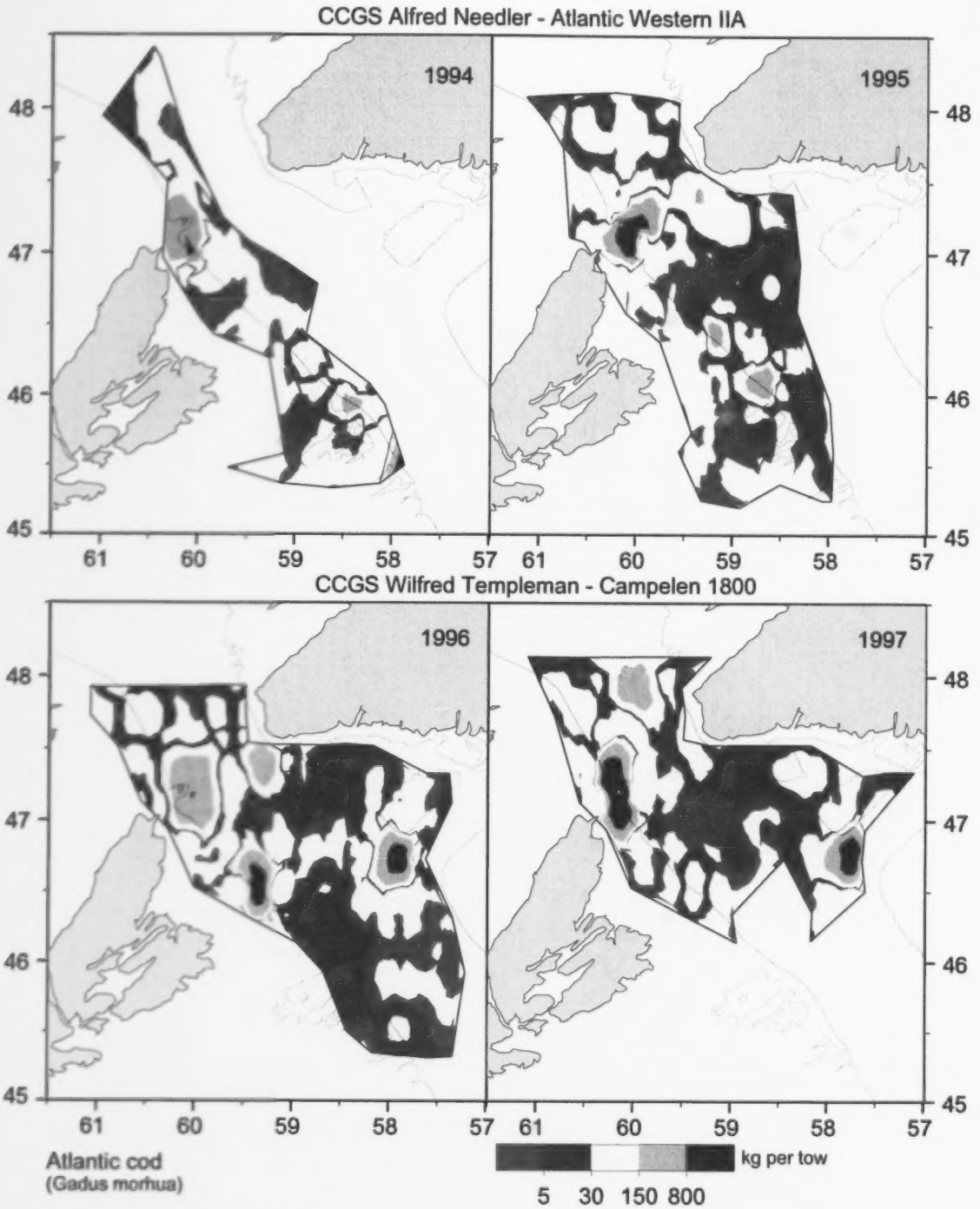

Figure 5a: Distribution of Atlantic cod (*Gadus morhua*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

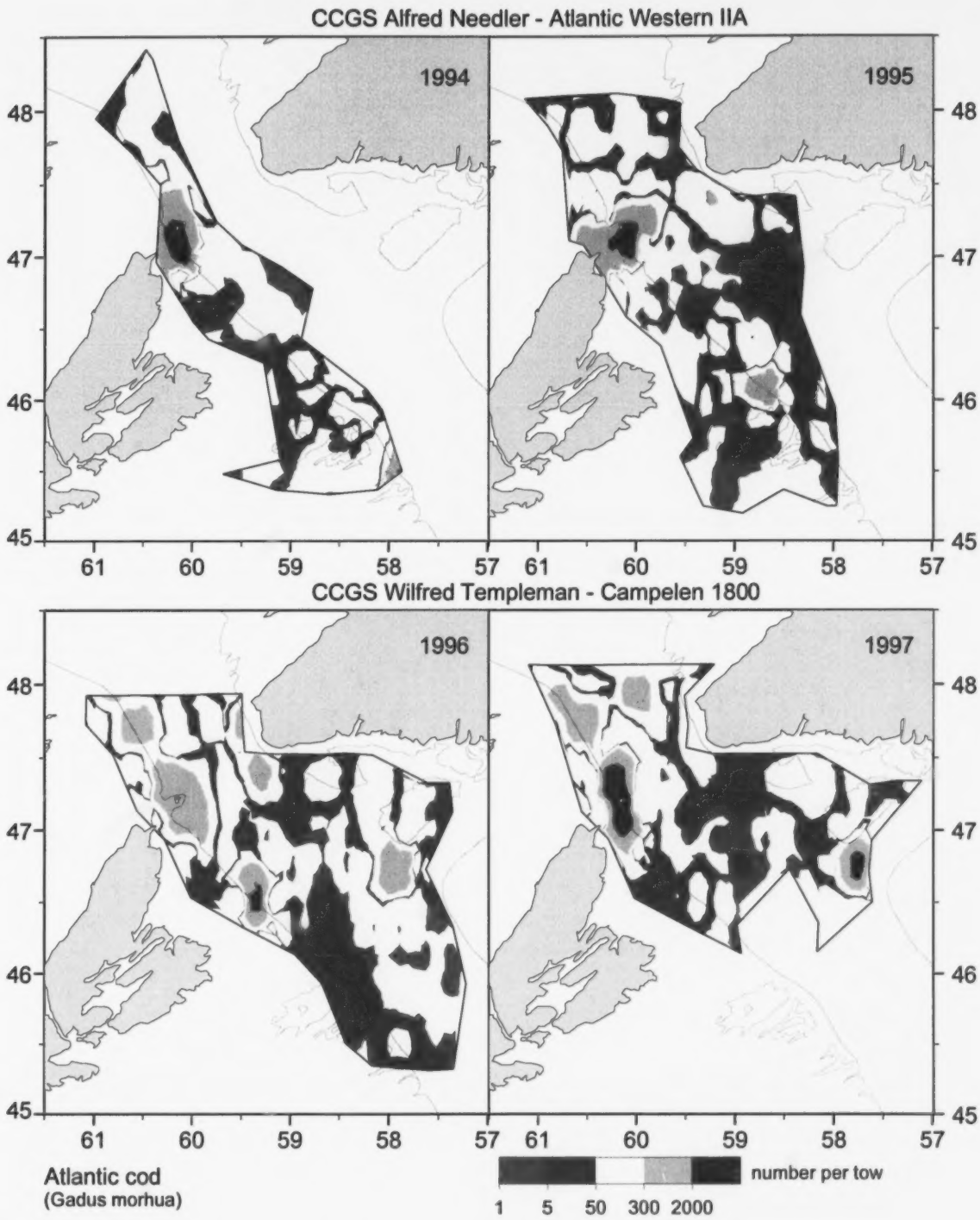

Figure 5b: Distribution of Atlantic cod (*Gadus morhua*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

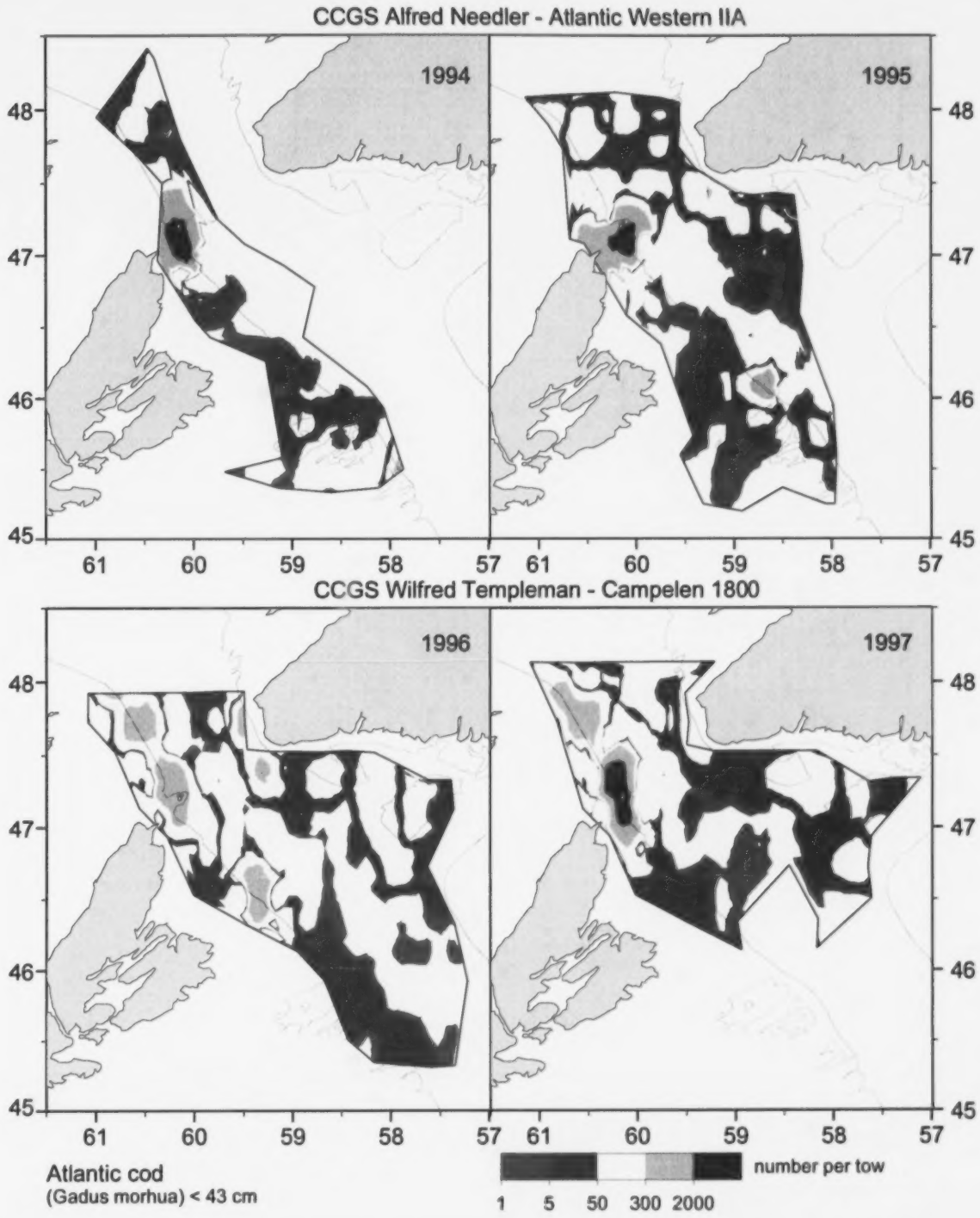

Figure 5c: Distribution of Atlantic cod (*Gadus morhua*) catches (number per tow) of fish less than 43 cm during January surveys conducted in Cabot Strait, 1994 –1997.

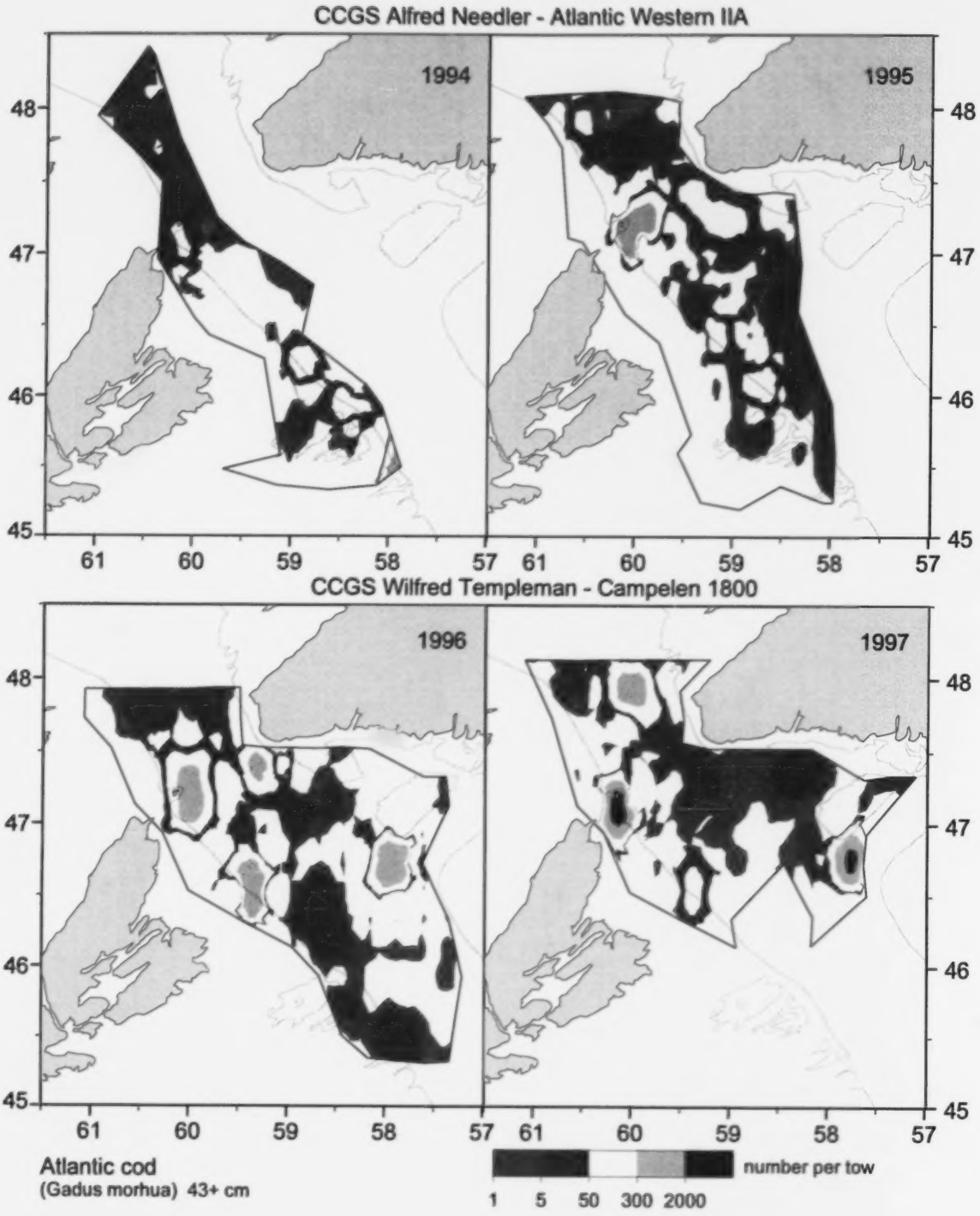

Figure 5d: Distribution of Atlantic cod (*Gadus morhua*) catches (number per tow) of fish 43 cm and larger during January surveys conducted in Cabot Strait, 1994 –1997.

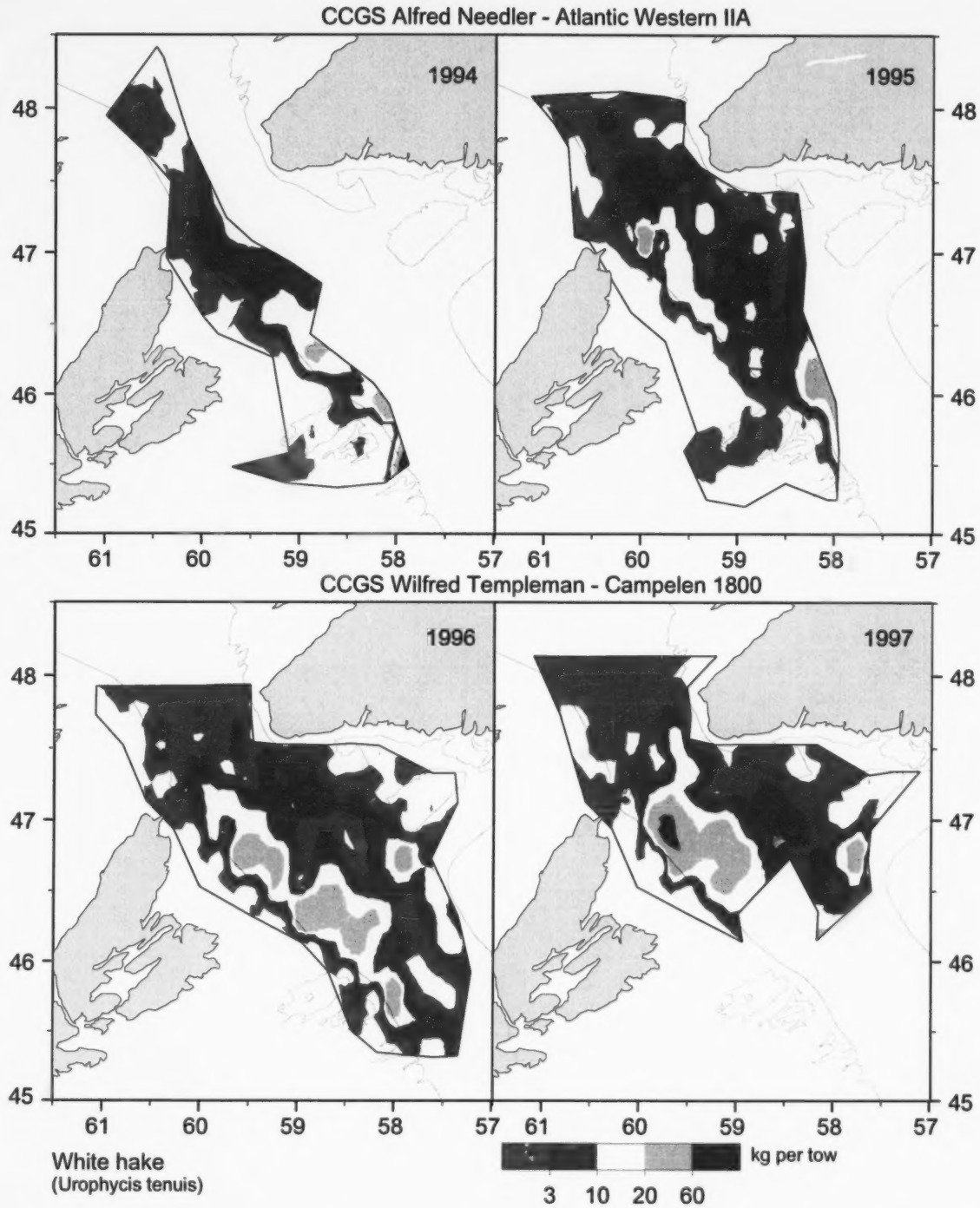

Figure 6a: Distribution of white hake (*Urophycis tenuis*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

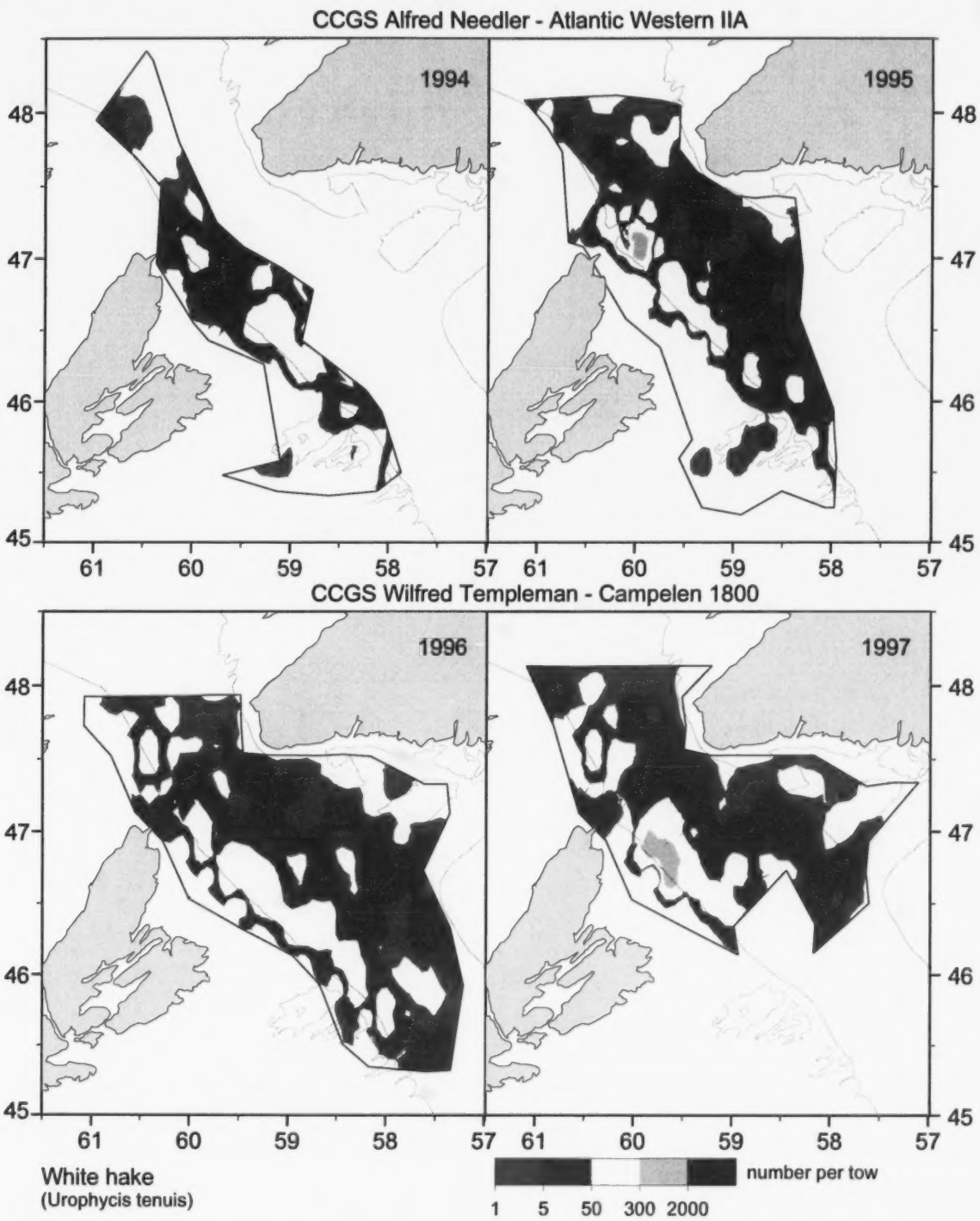

Figure 6b: Distribution of white hake (*Urophycis tenuis*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

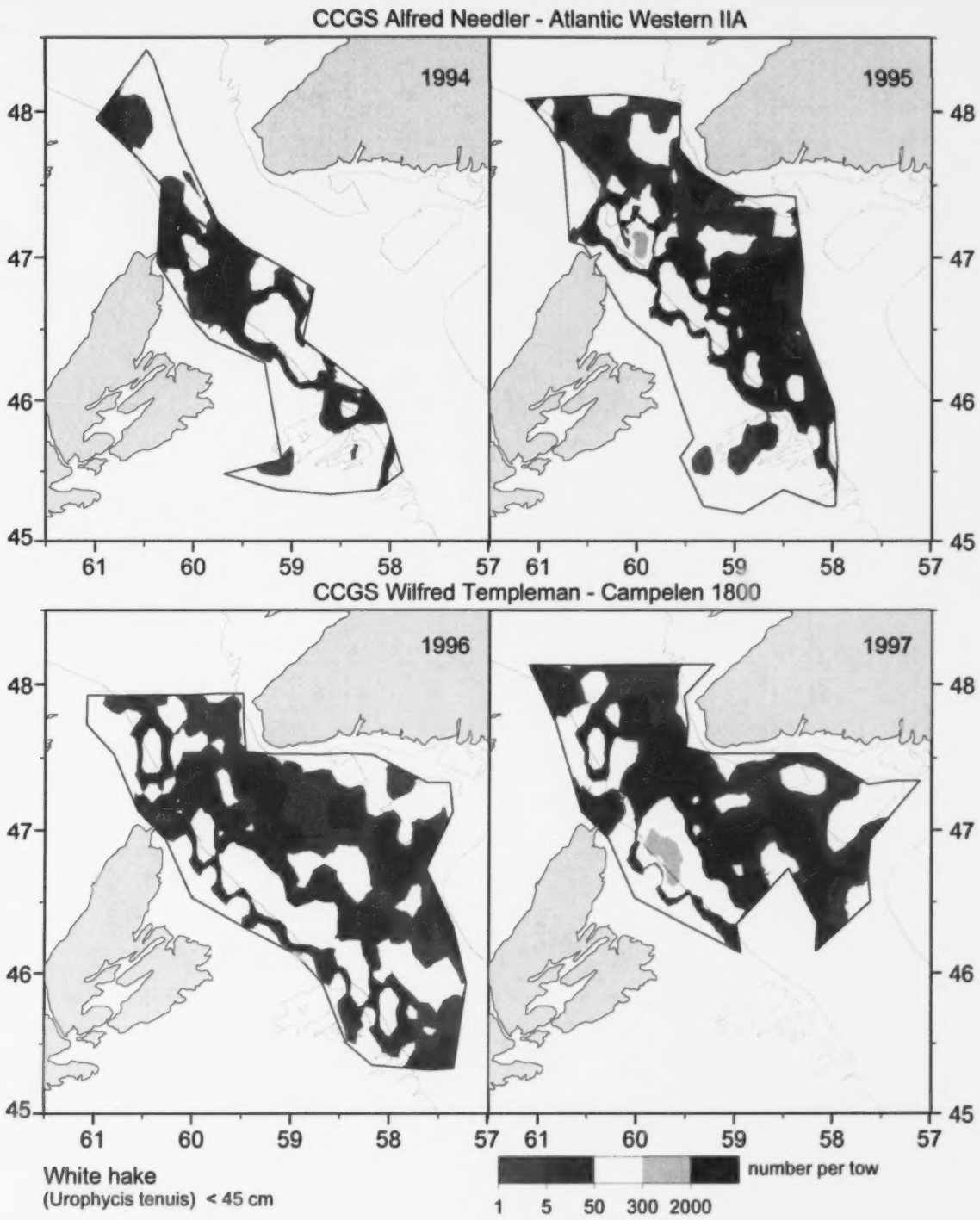

Figure 6c: Distribution of white hake (*Urophycis tenuis*) catches (number per tow) of fish less than 45 cm during January surveys conducted in Cabot Strait, 1994 –1997.

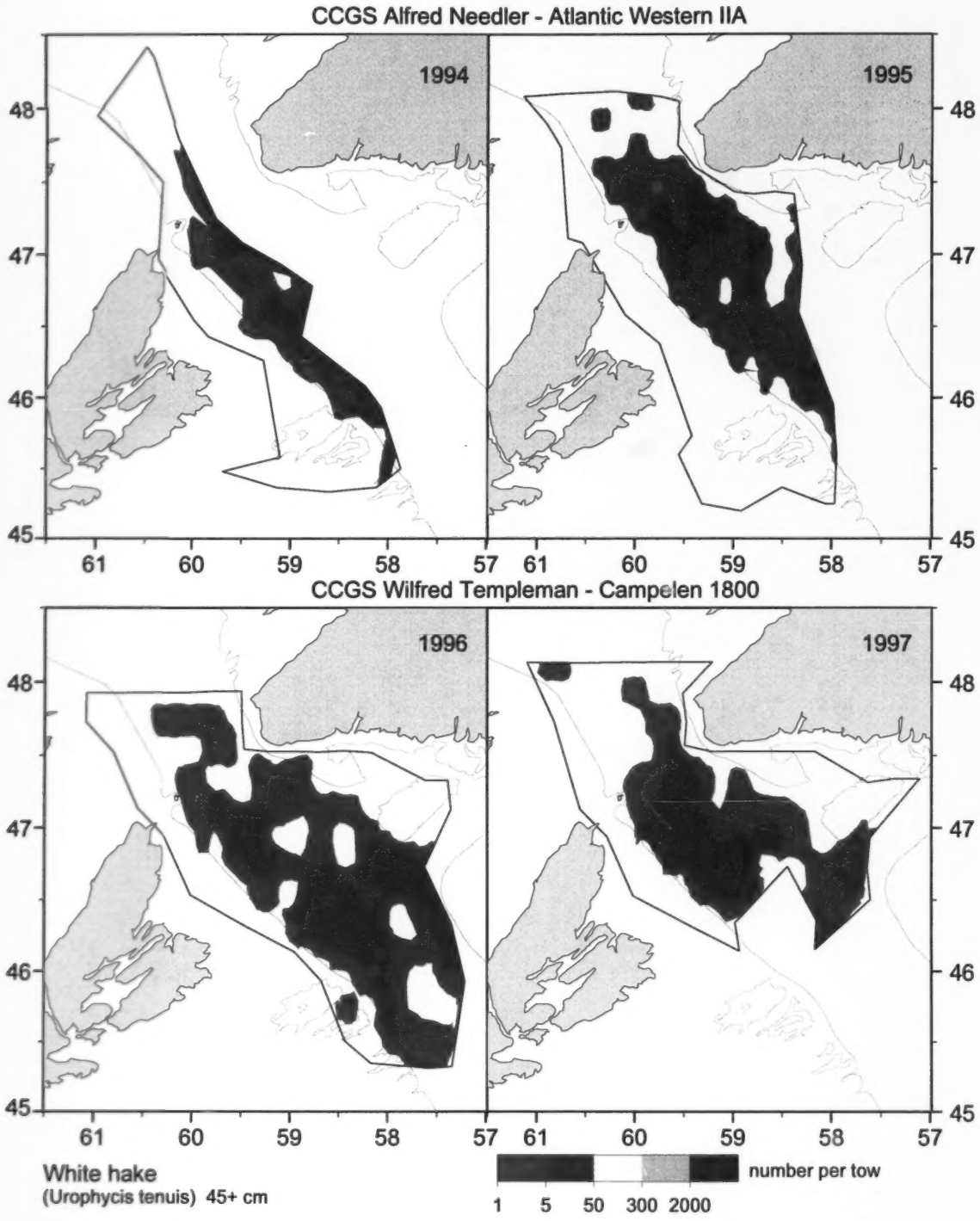

Figure 6d: Distribution of white hake (*Urophycis tenuis*) catches (number per tow) of fish 45 cm and larger during January surveys conducted in Cabot Strait, 1994 –1997.

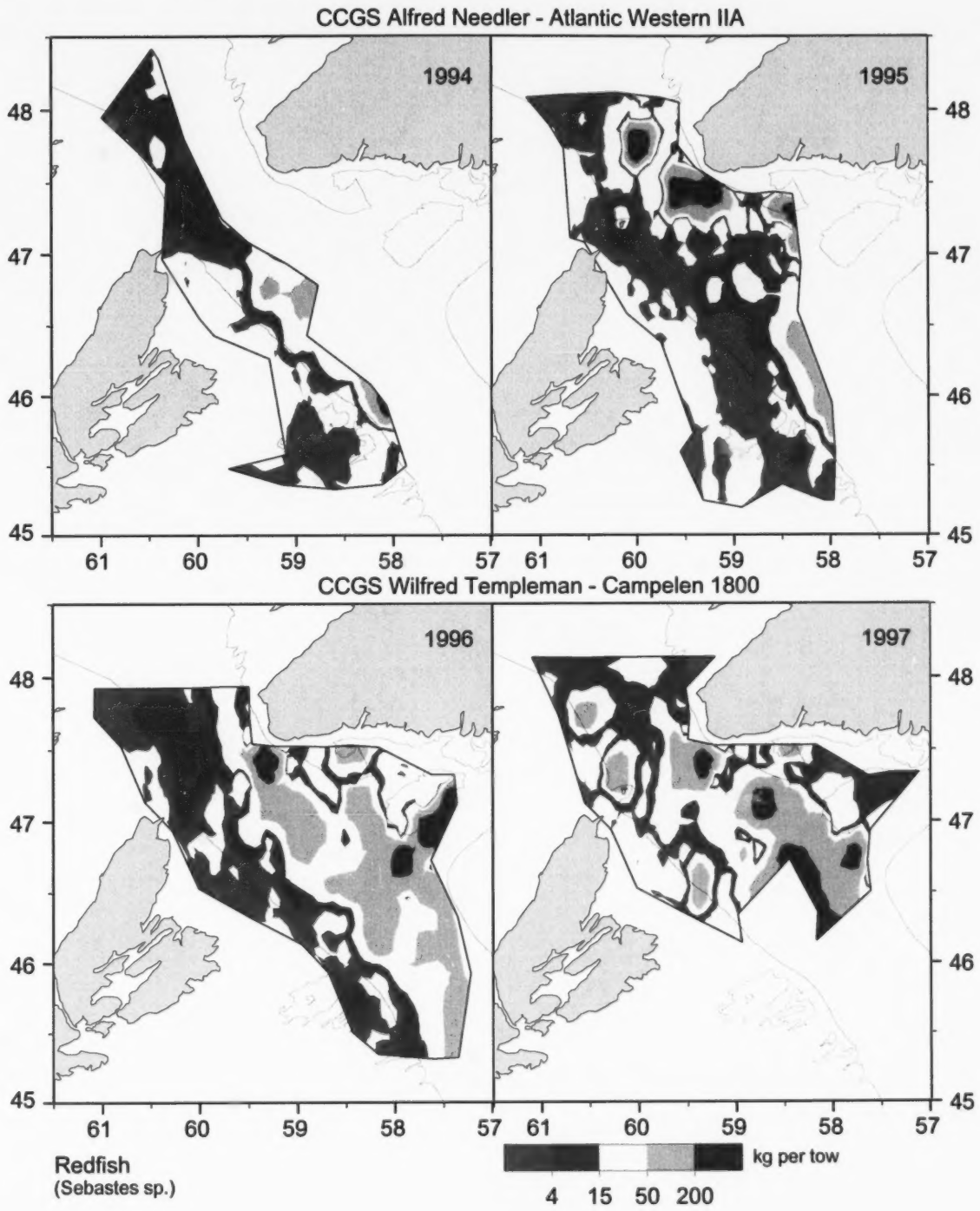

Figure 7a: Distribution of redfish (*Sebastes sp.*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

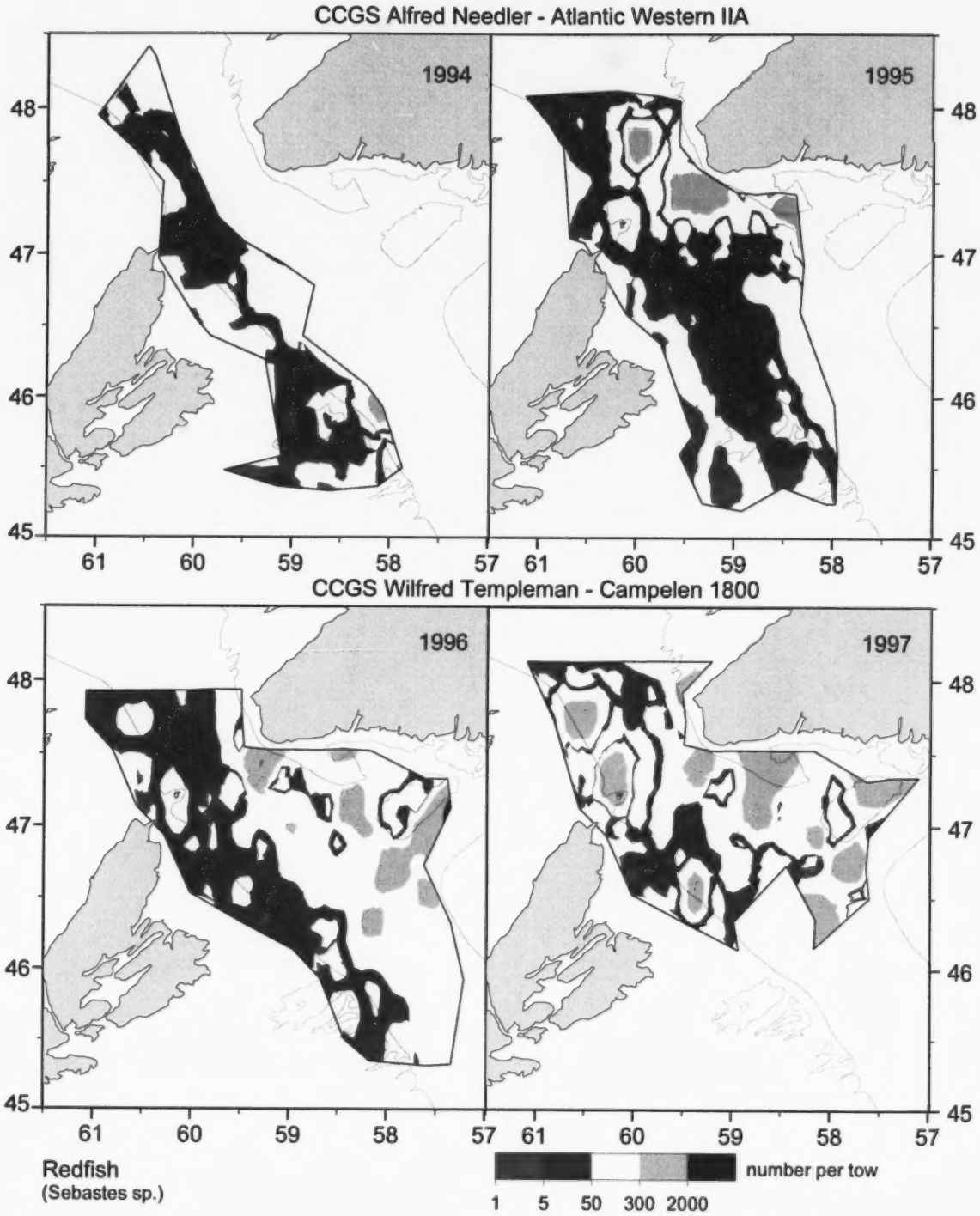

Figure 7b: Distribution of redfish (*Sebastes sp.*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

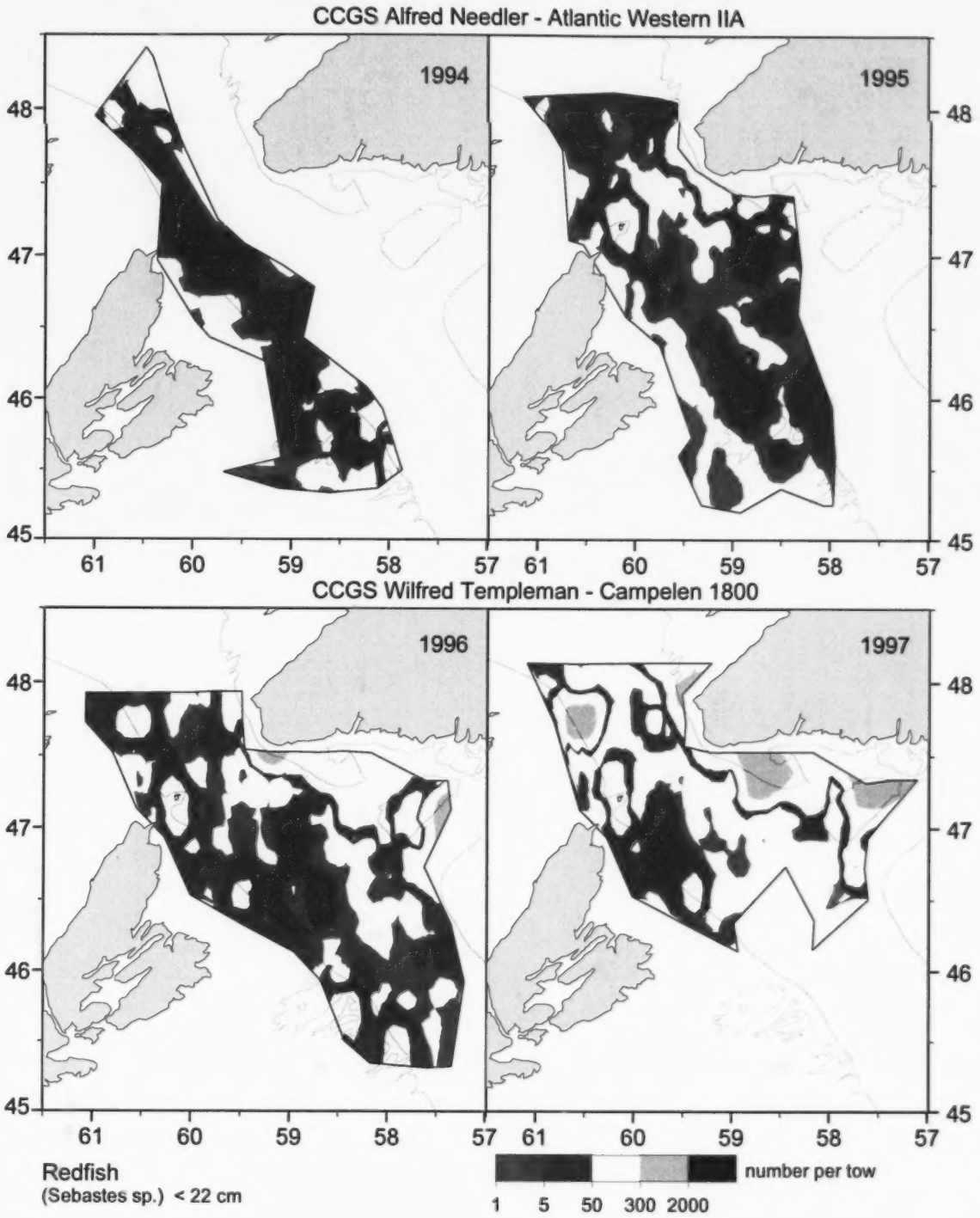

Figure 7c: Distribution of redfish (*Sebastes sp.*) catches (number per tow) of fish less than 22 cm during January surveys conducted in Cabot Strait, 1994 –1997.

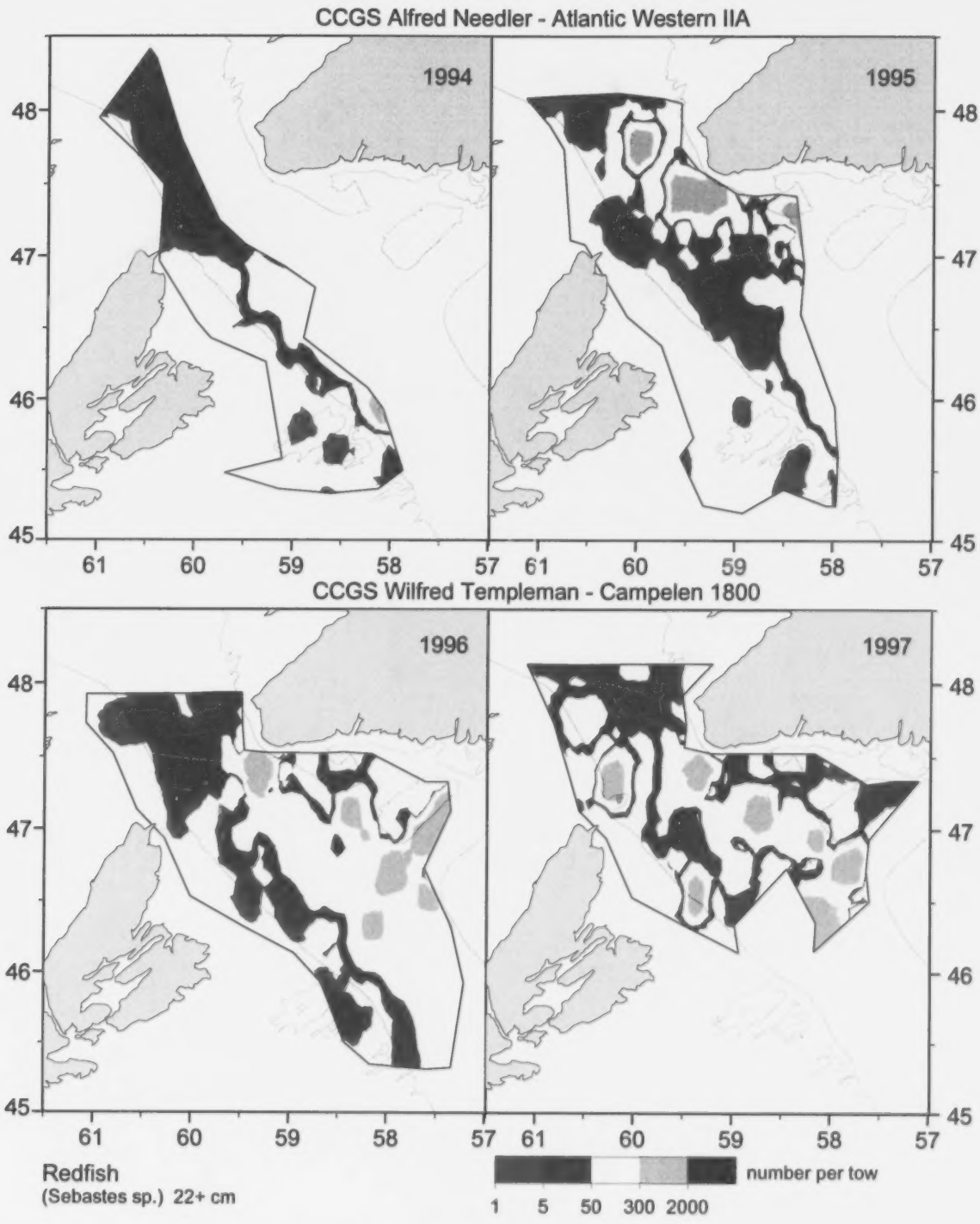

Figure 7d: Distribution of redfish (*Sebastes sp.*) catches (number per tow) of fish 22 cm and larger during January surveys conducted in Cabot Strait, 1994 –1997.

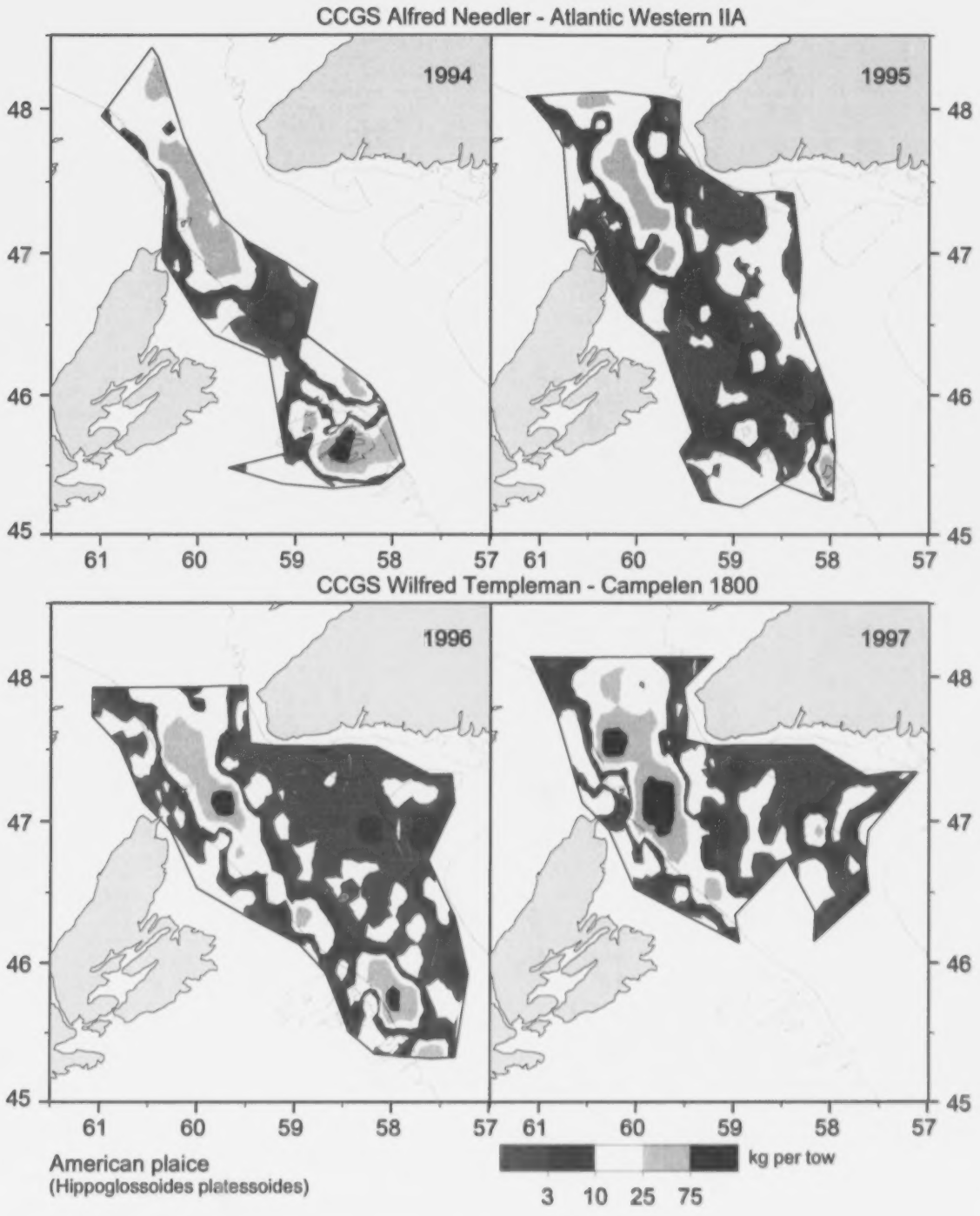

Figure 8a: Distribution of American plaice (*Hippoglossoides platessoides*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

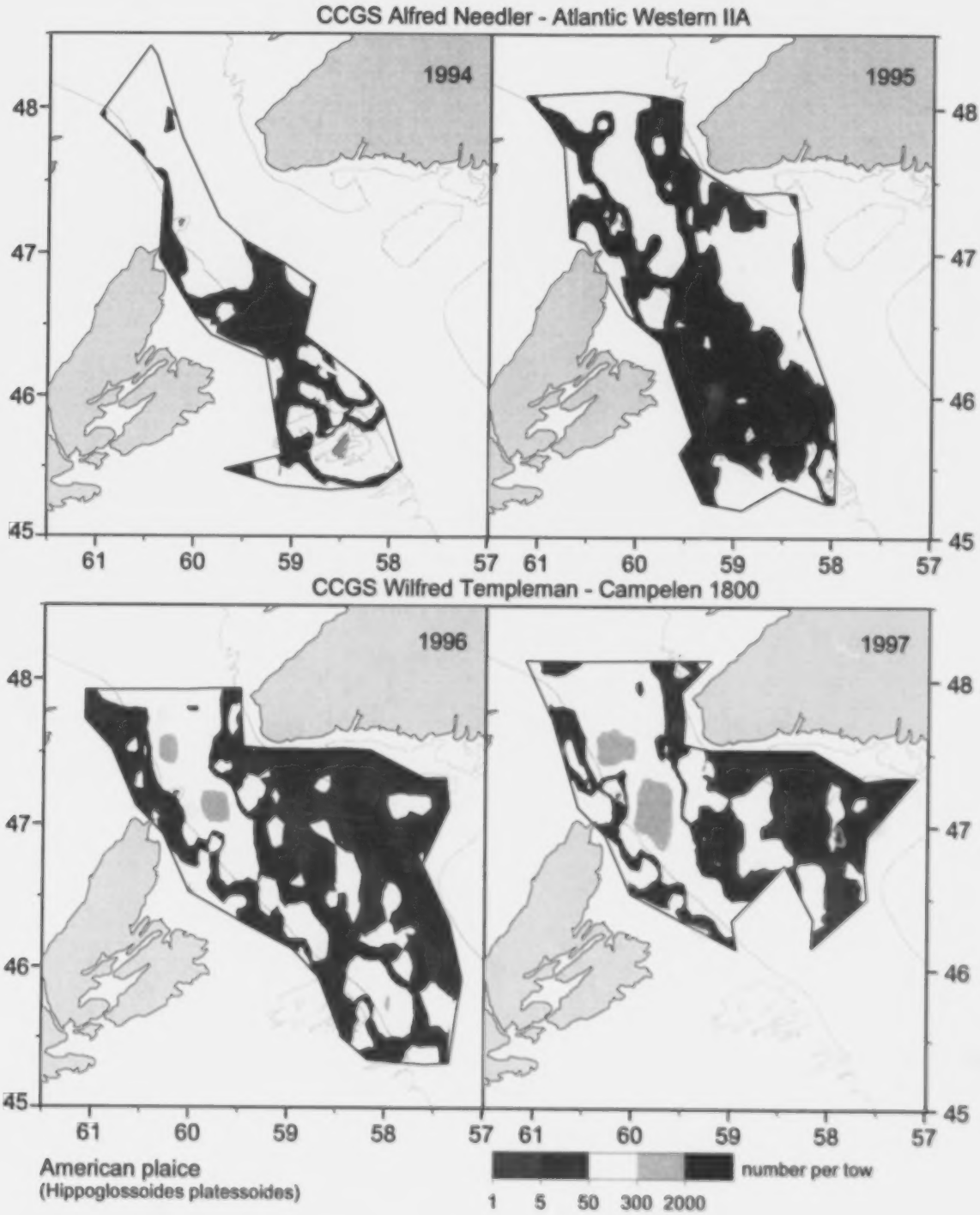

Figure 8b: Distribution of American plaice (*Hippoglossoides platessoides*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

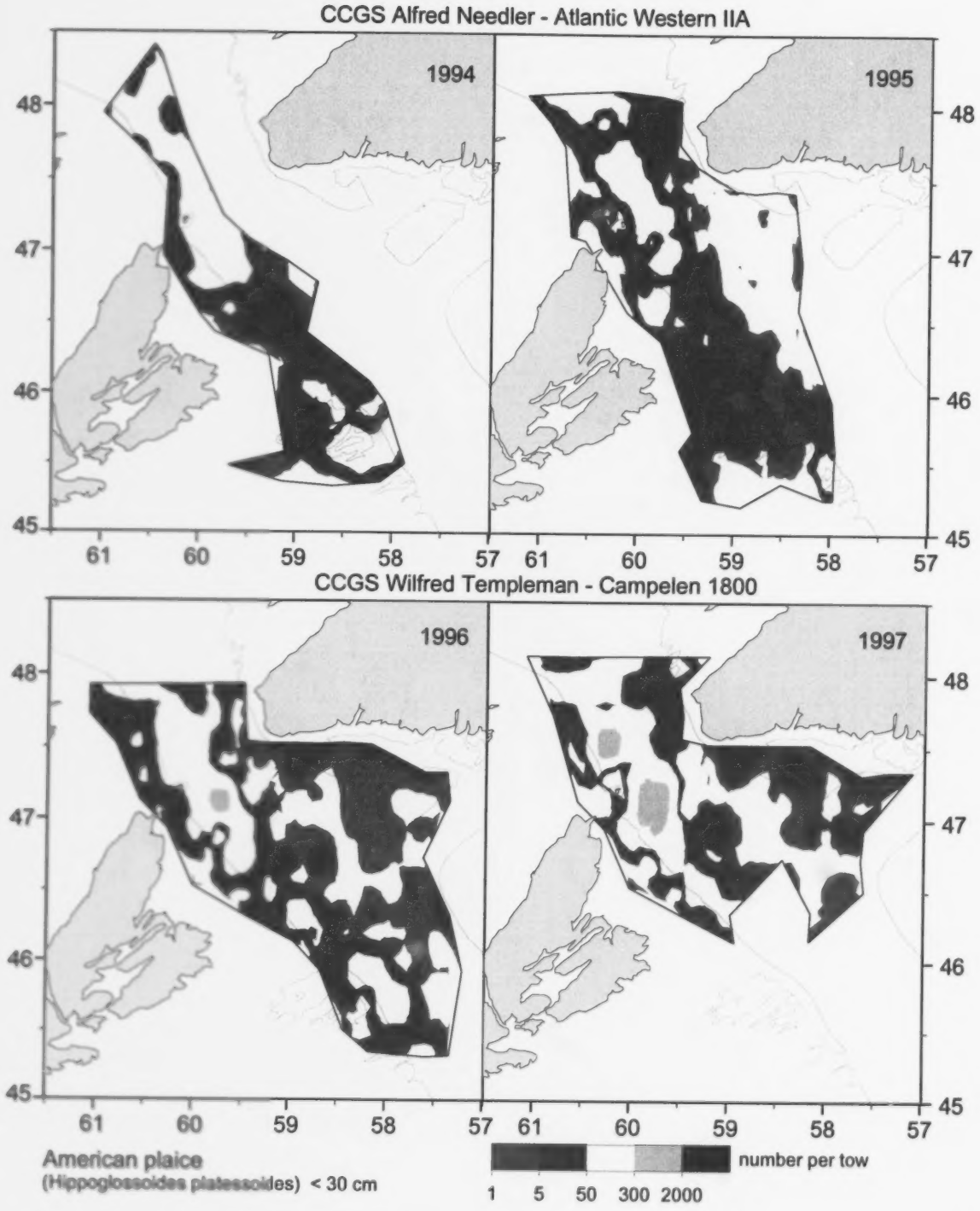

Figure 8c: Distribution of American plaice (*Hippoglossoides platessoides*) catches (number per tow) of fish less than 30 cm during January surveys conducted in Cabot Strait, 1994 –1997.

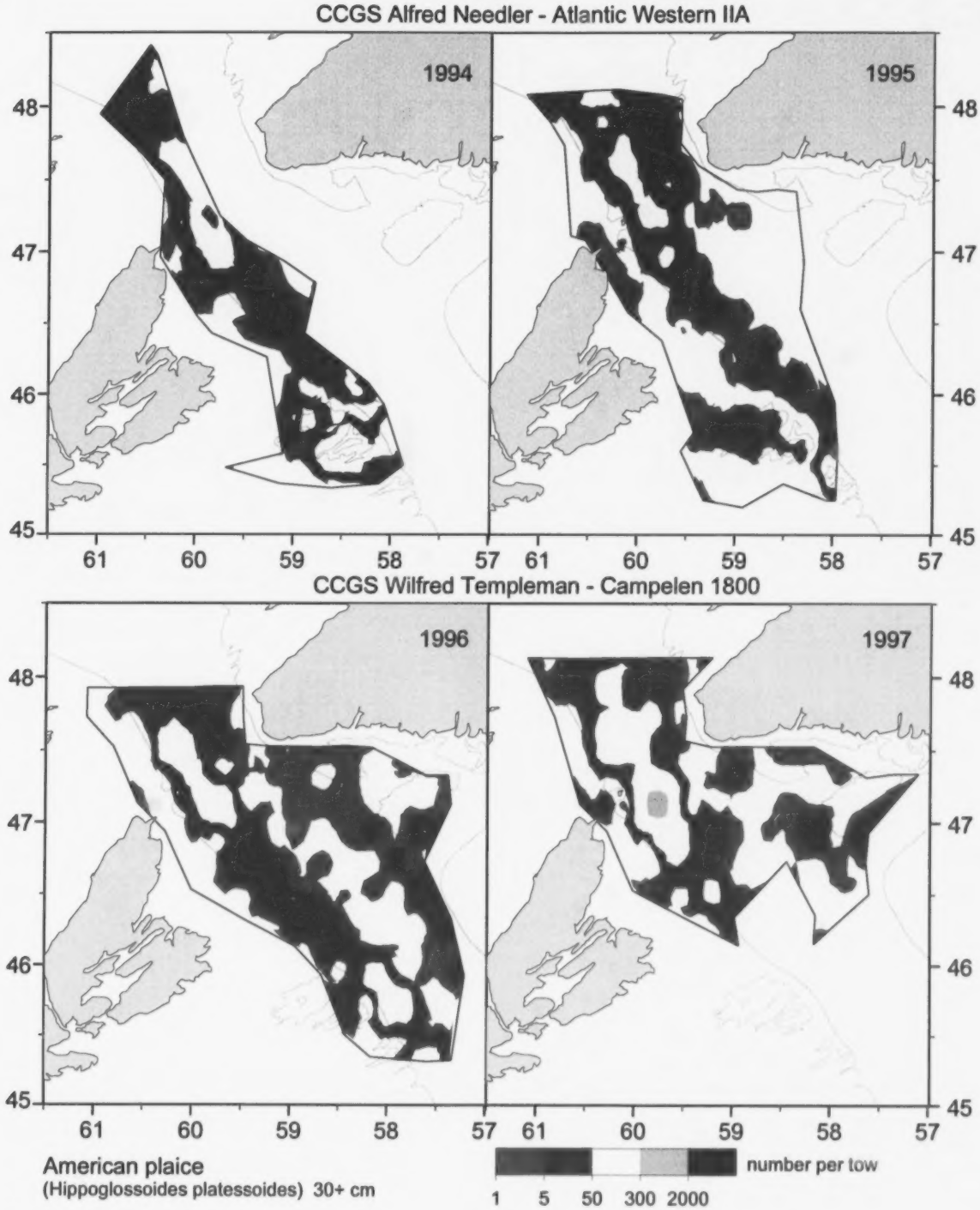

Figure 8d: Distribution of American plaice (*Hippoglossoides platessoides*) catches (number per tow) of fish 30 cm and larger during January surveys conducted in Cabot Strait, 1994 –1997.

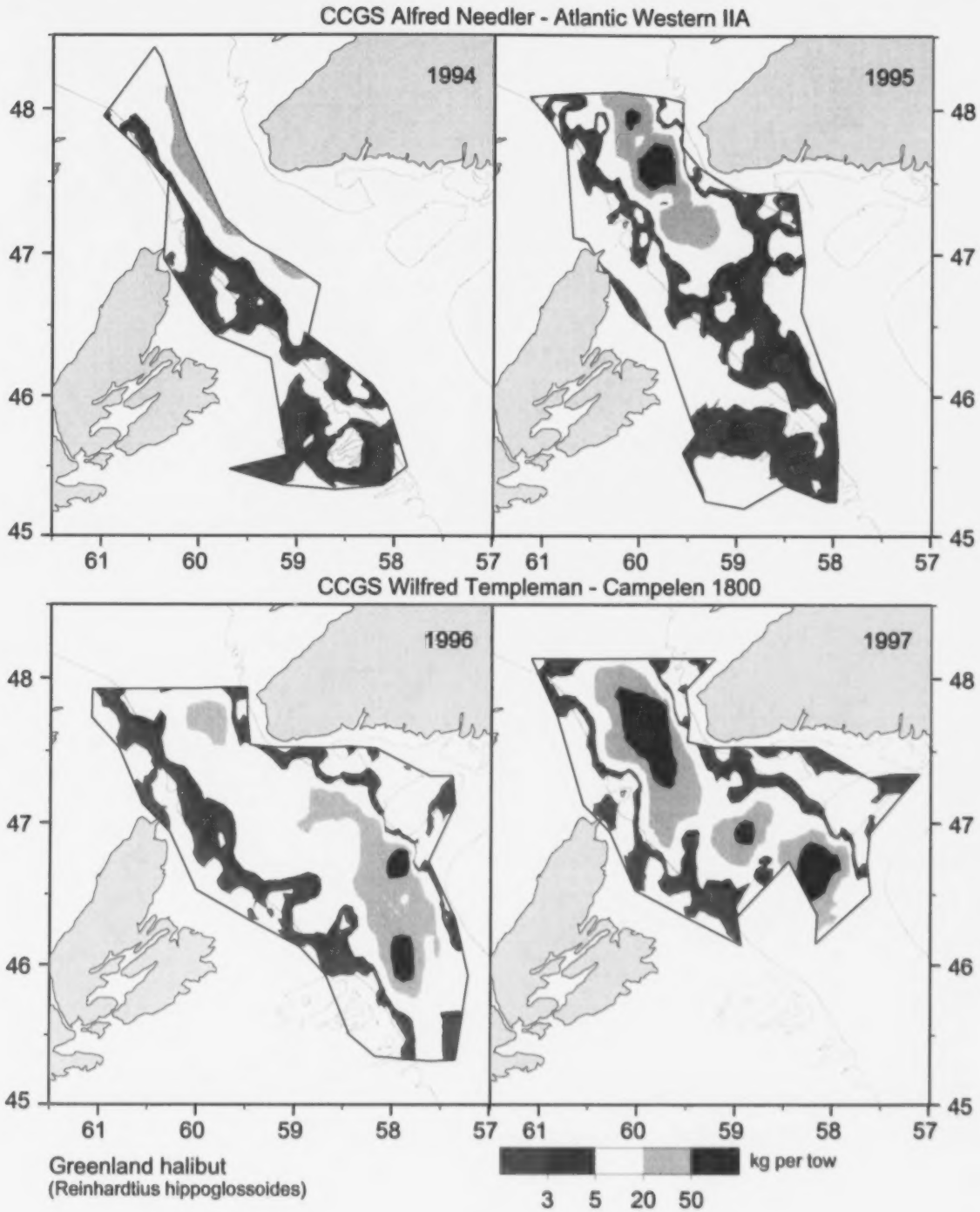

Figure 9a: Distribution of Greenland halibut (*Reinhardtius hippoglossoides*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

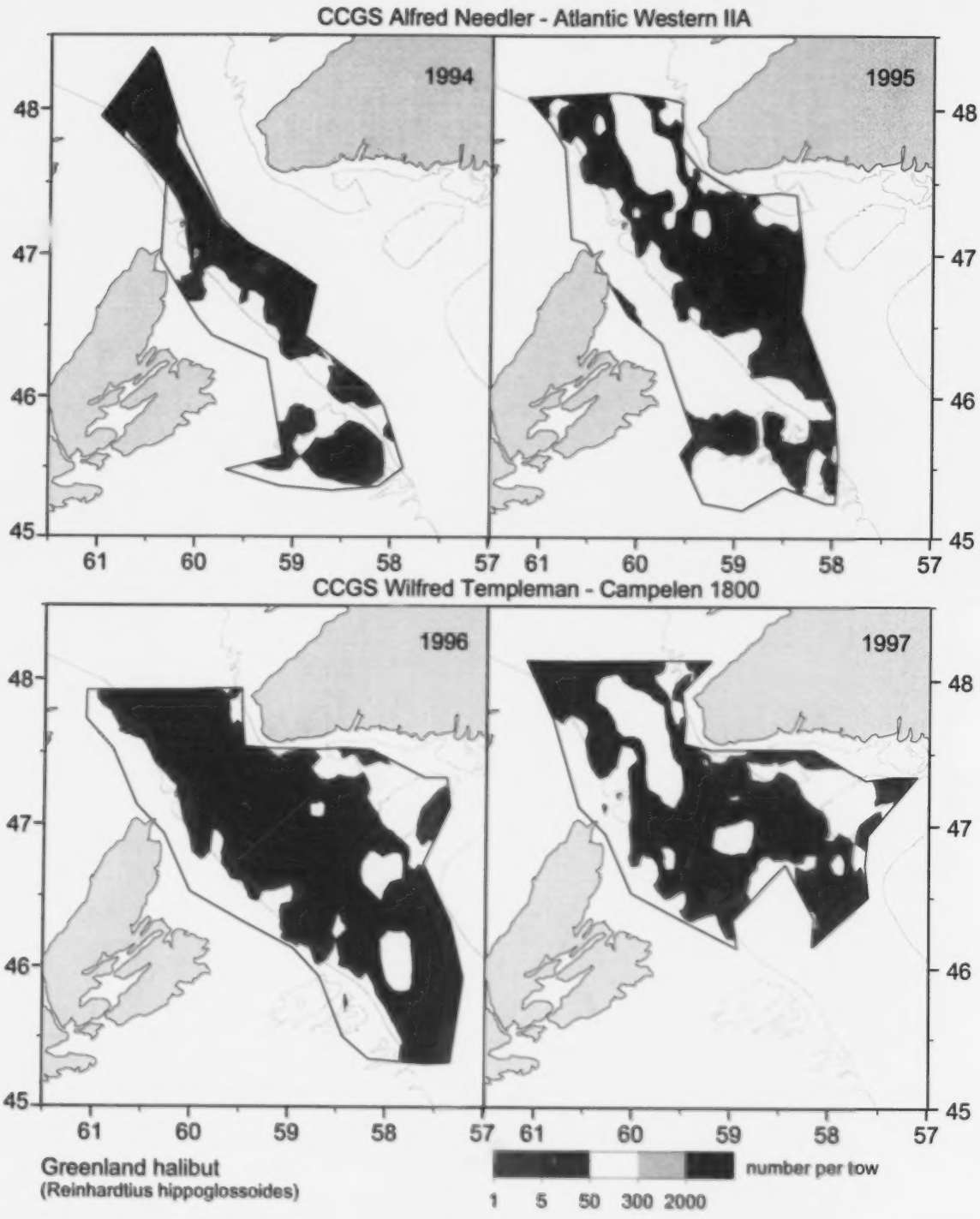

Figure 9b: Distribution of Greenland halibut (*Reinhardtius hippoglossoides*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

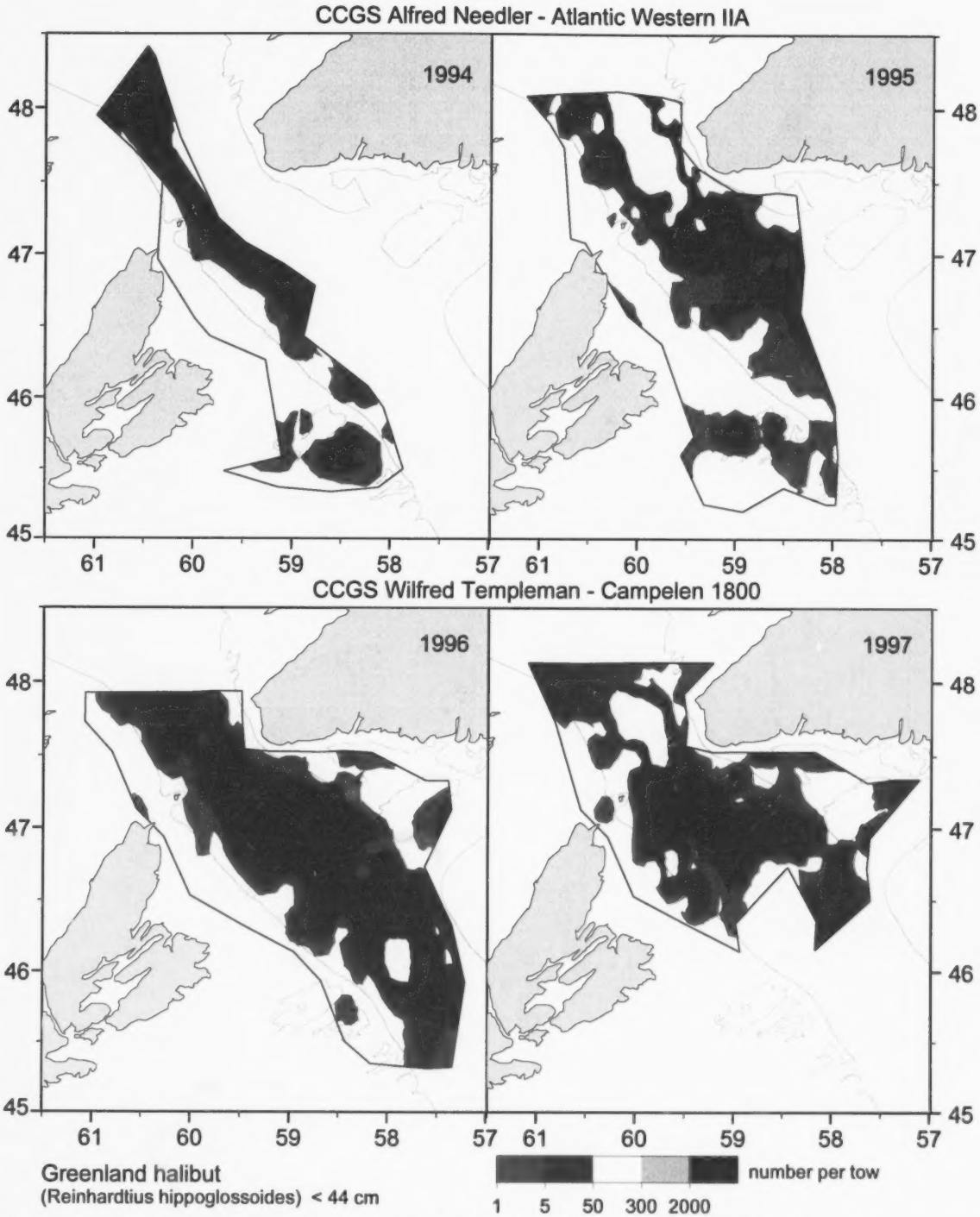

Figure 9c: Distribution of Greenland halibut (*Reinhardtius hippoglossoides*) catches (number per tow) of fish less than 44 cm during January surveys conducted in Cabot Strait, 1994 –1997.

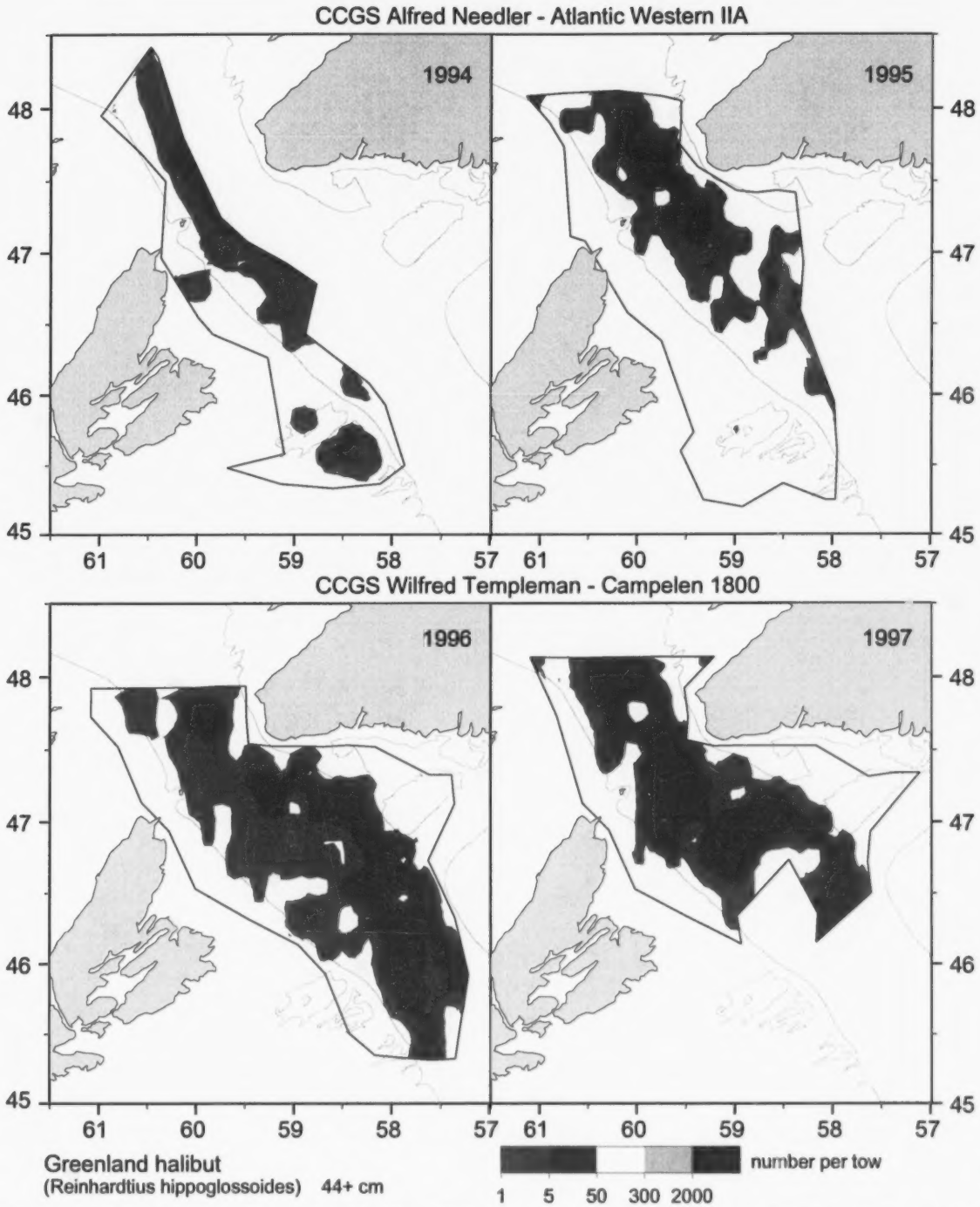

Figure 9d: Distribution of Greenland halibut (*Reinhardtius hippoglossoides*) catches (number per tow) of fish 44 cm and larger during January surveys conducted in Cabot Strait, 1994 –1997.

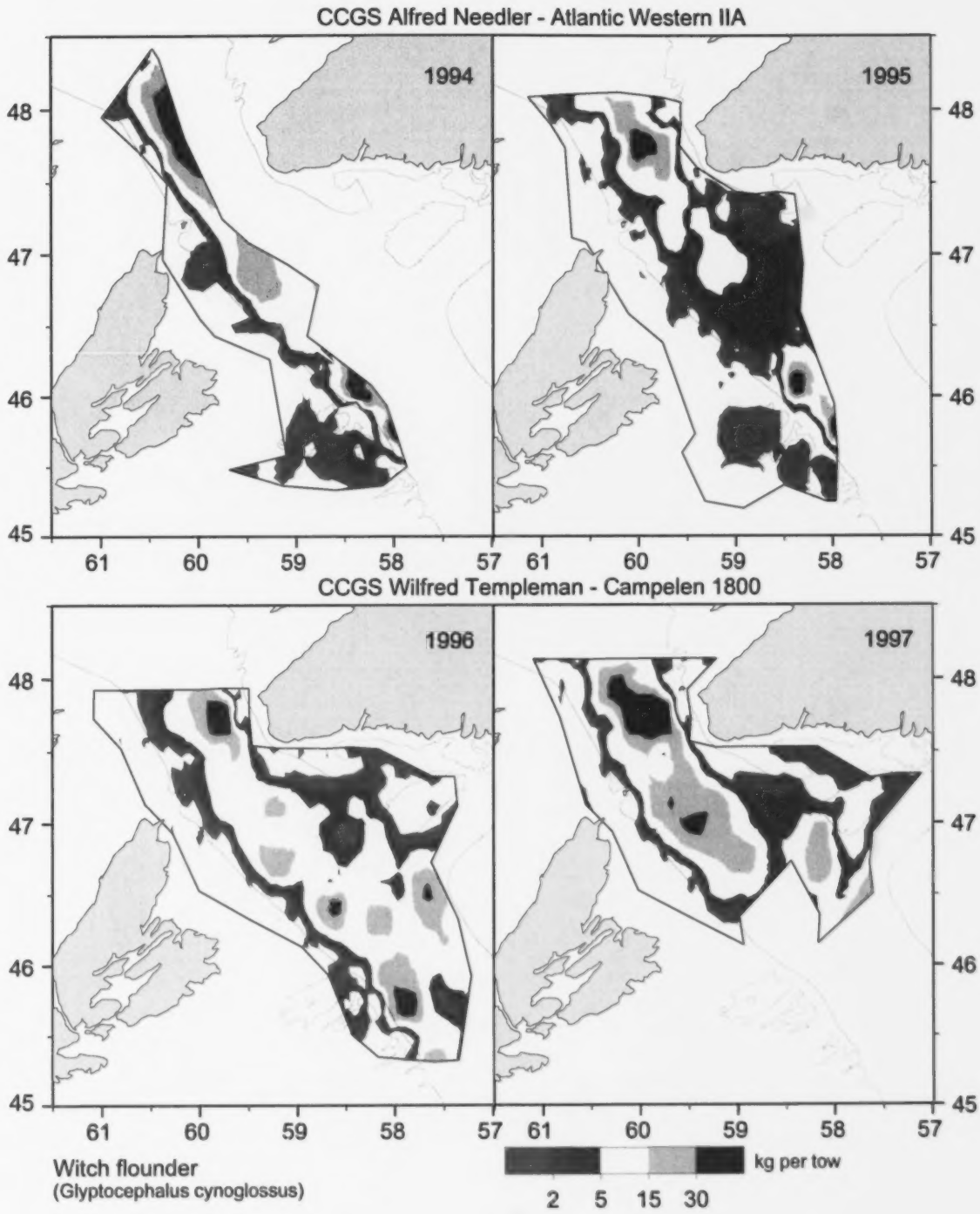

Figure 10a: Distribution of witch flounder (*Glyptocephalus cynoglossus*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

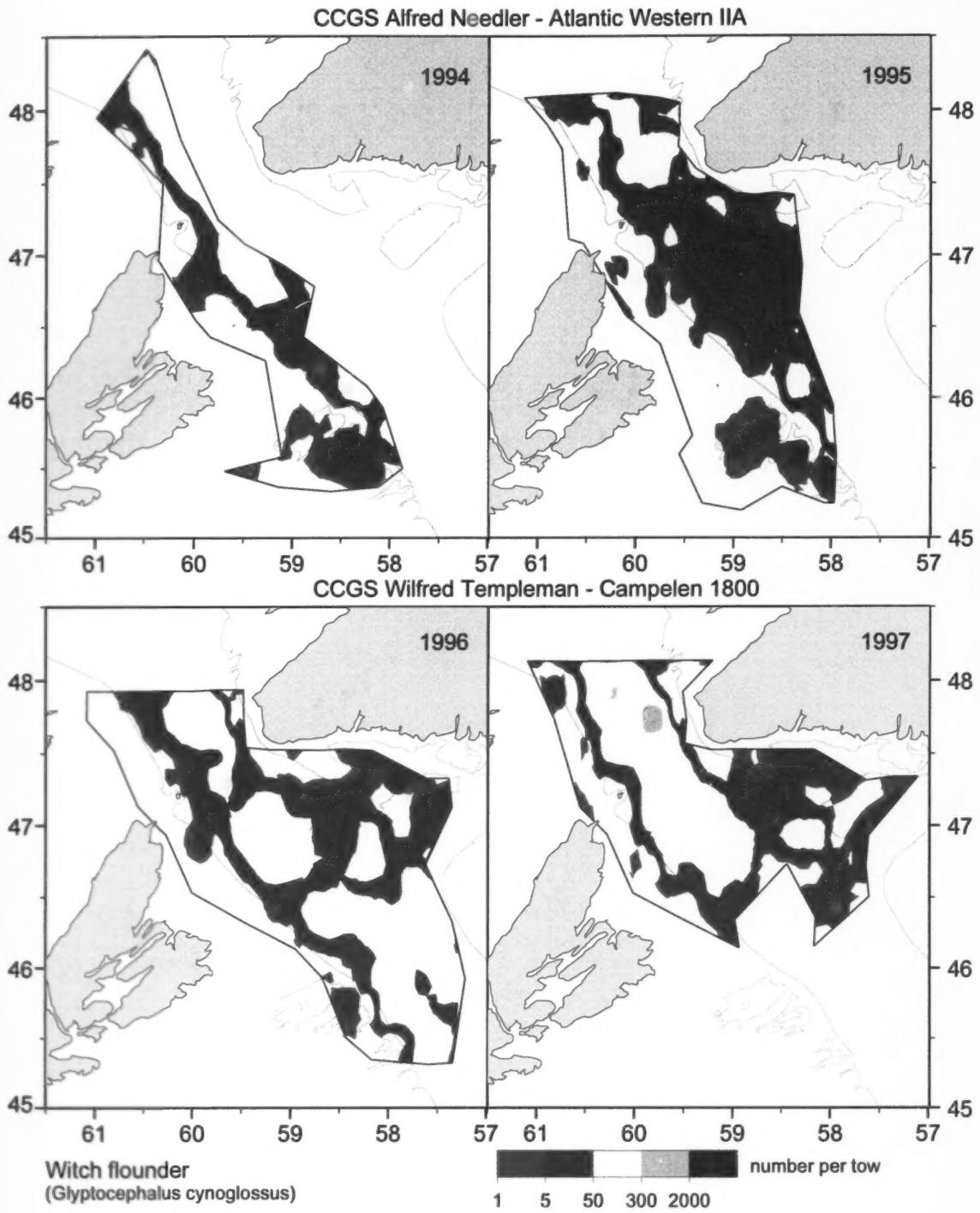

Figure 10b: Distribution of witch flounder (*Glyptocephalus cynoglossus*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

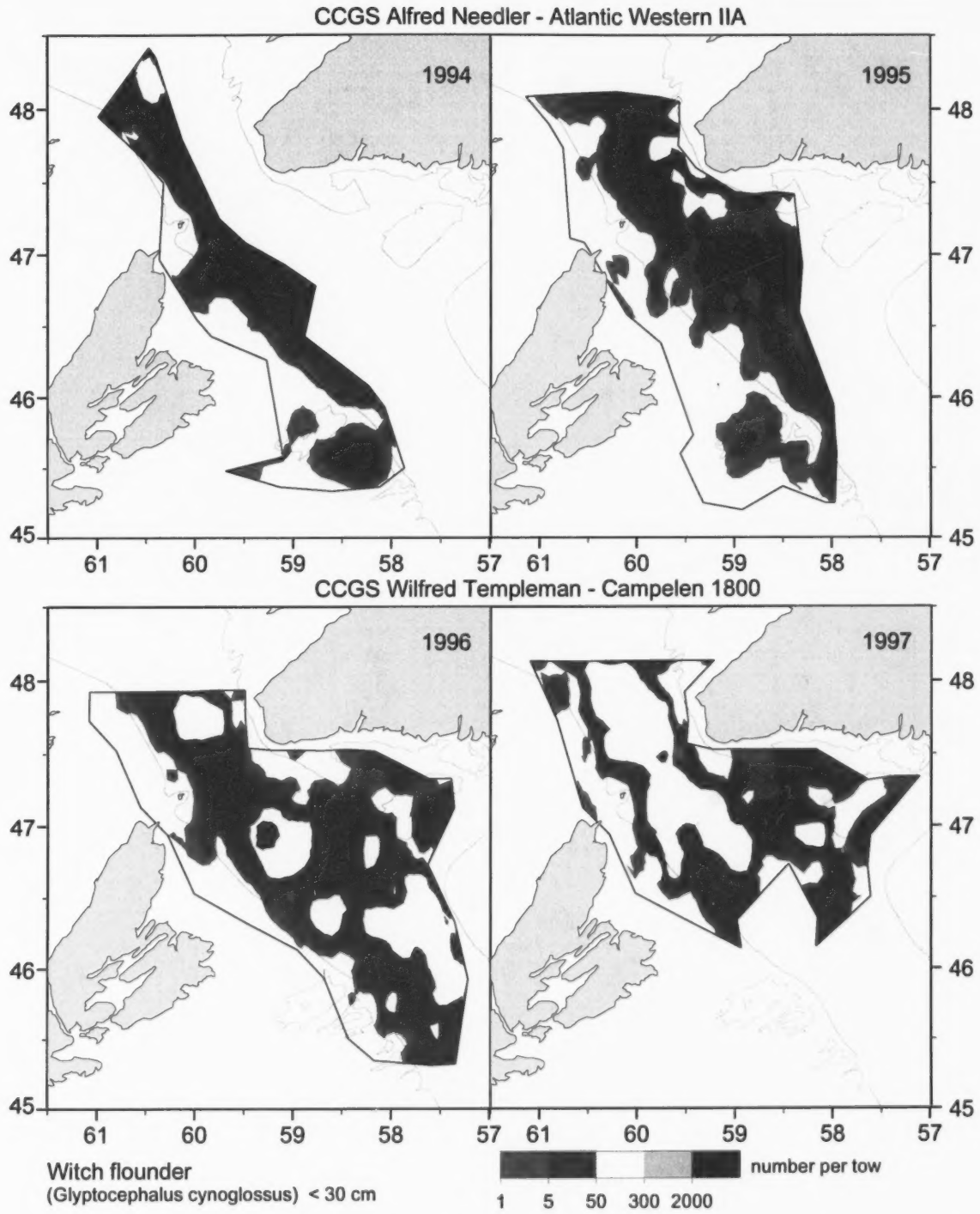

Figure 10c: Distribution of witch flounder (*Glyptocephalus cynoglossus*) catches (number per tow) of fish less than 30 cm during January surveys conducted in Cabot Strait, 1994 –1997.

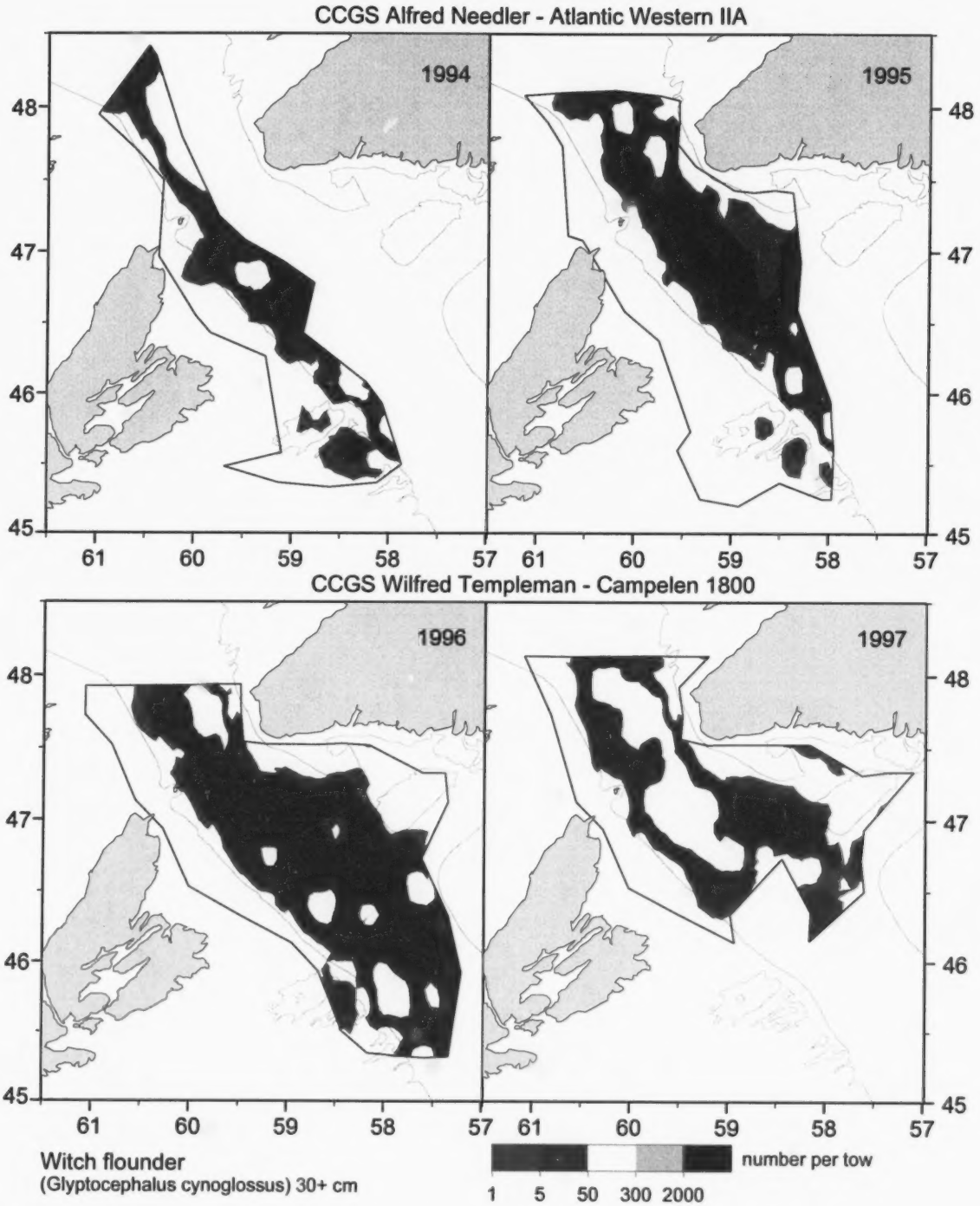

Figure 10d: Distribution of witch flounder (*Glyptocephalus cynoglossus*) catches (number per tow) of fish 30 cm and larger during January surveys conducted in Cabot Strait, 1994 –1997.

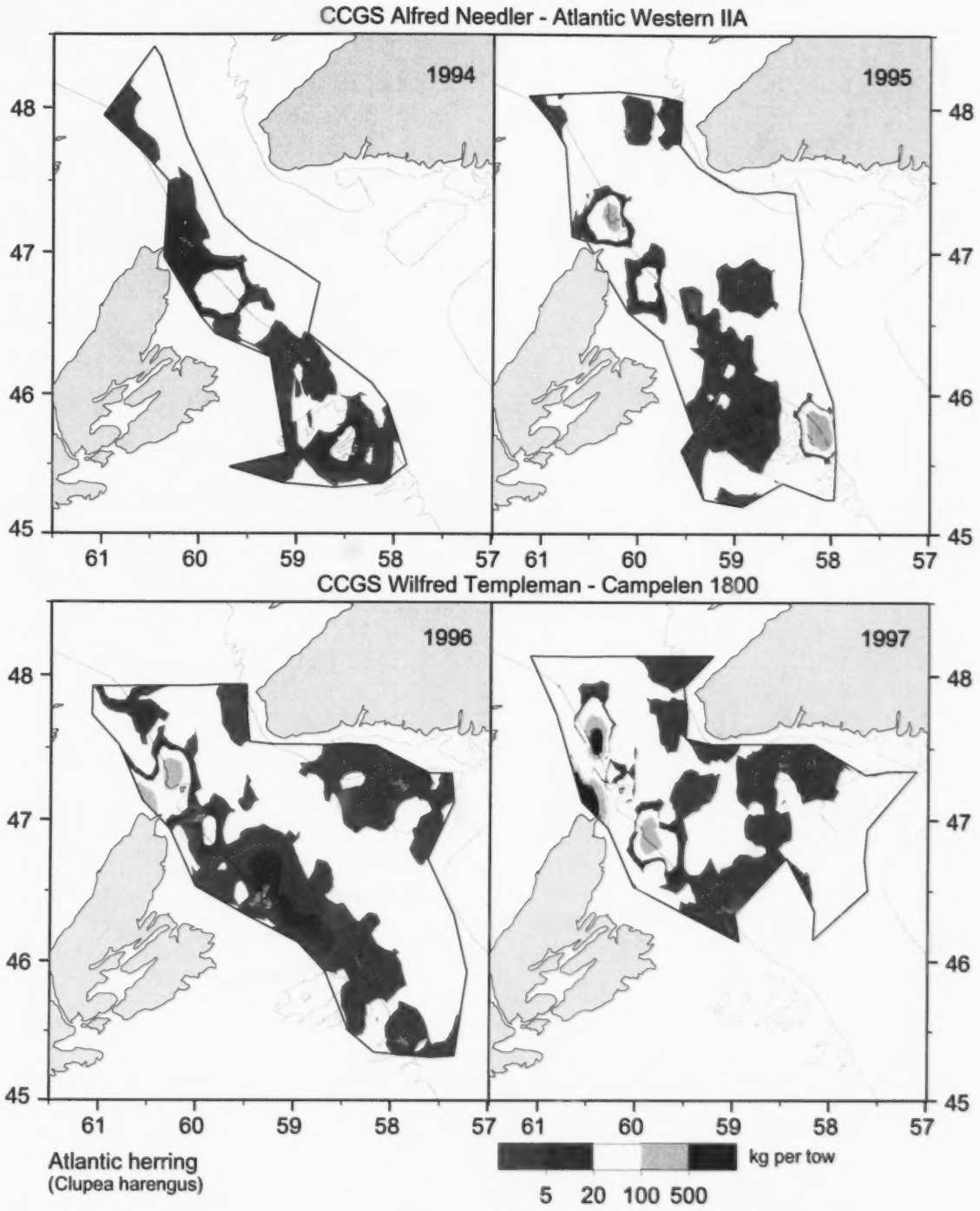

Figure 11a: Distribution of Atlantic herring (*Clupea harengus*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

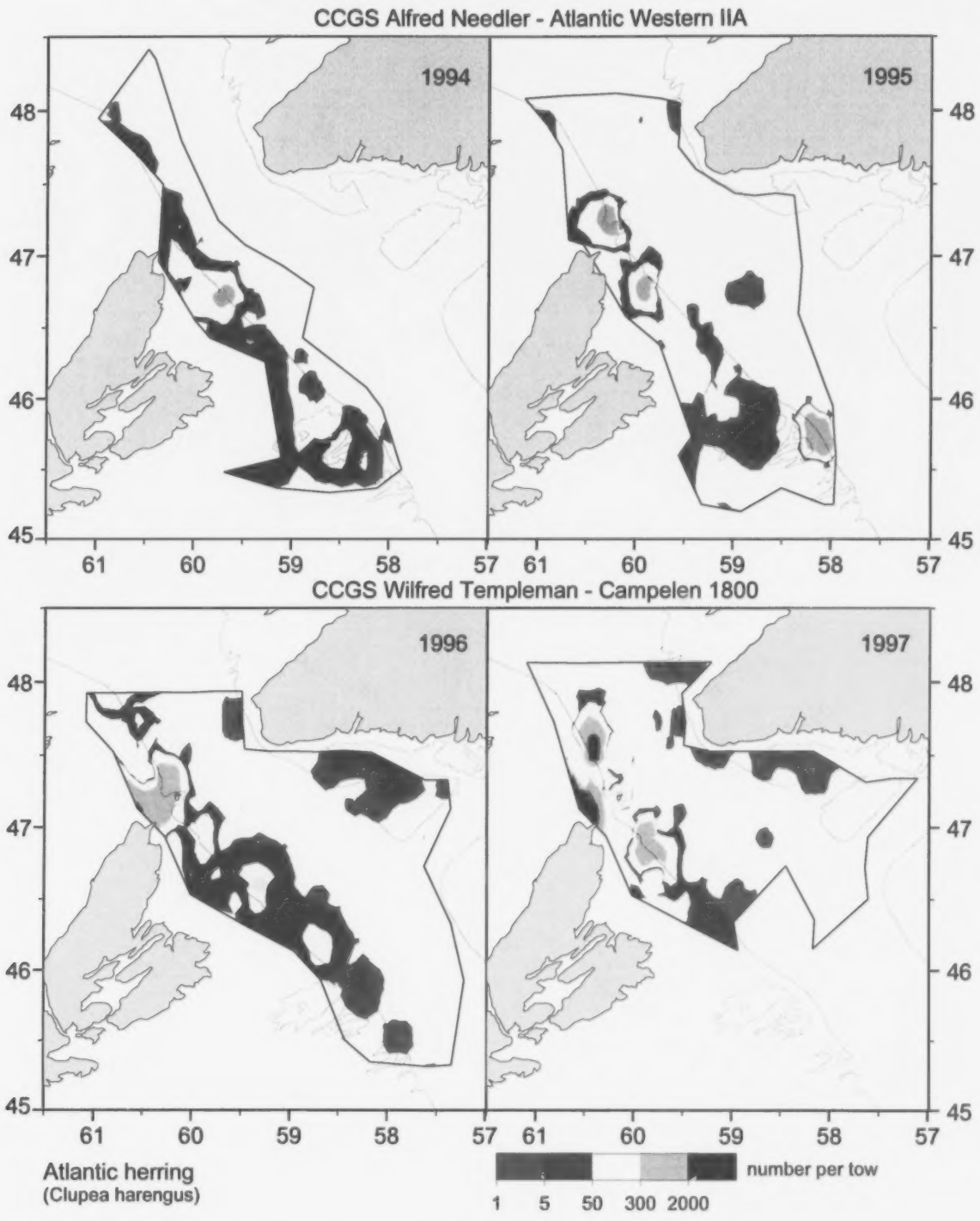

Figure 11b: Distribution of Atlantic herring (*Clupea harengus*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

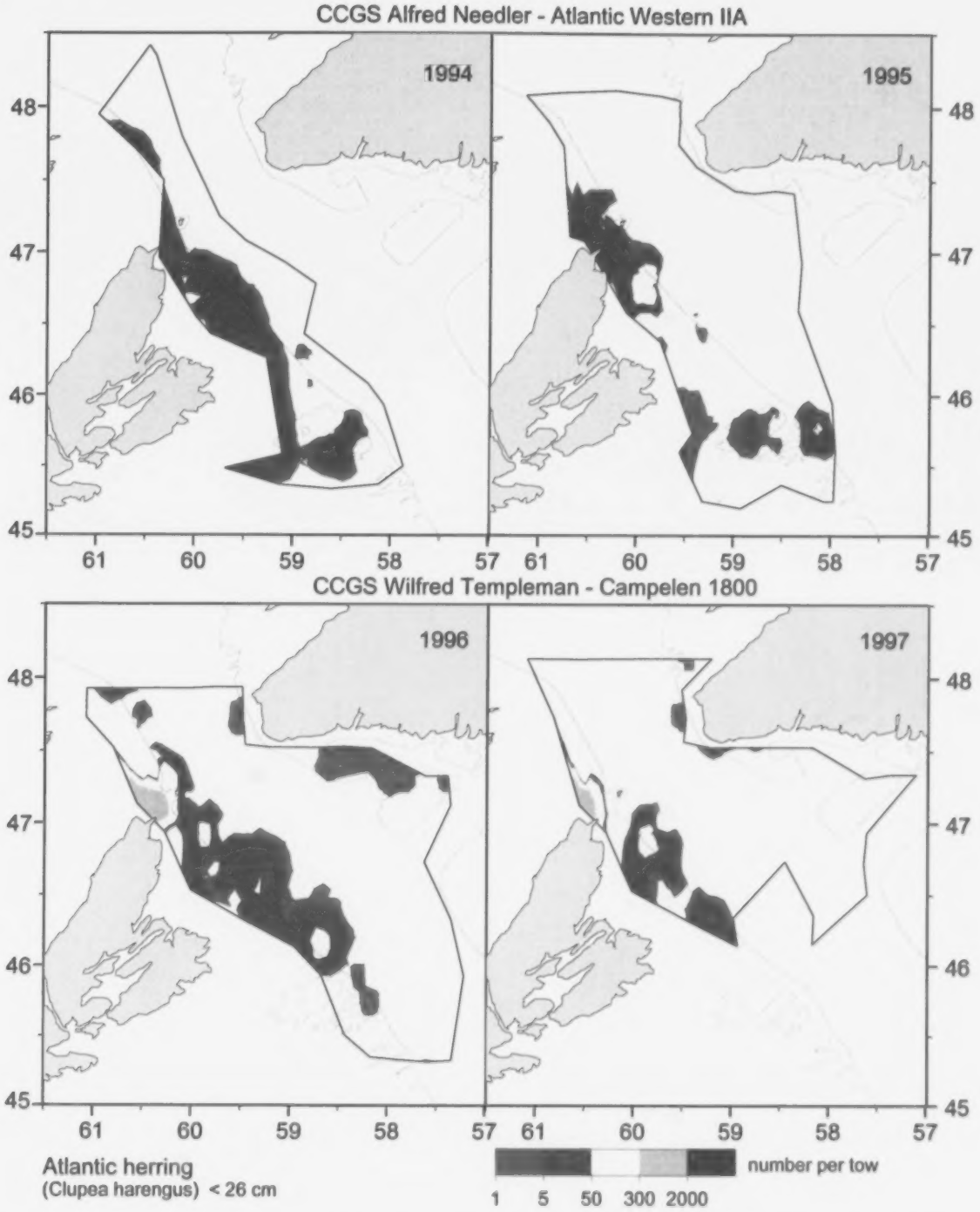

Figure 11c: Distribution of Atlantic herring (*Clupea harengus*) catches (number per tow) of fish less than 26 cm during January surveys conducted in Cabot Strait, 1994 –1997.

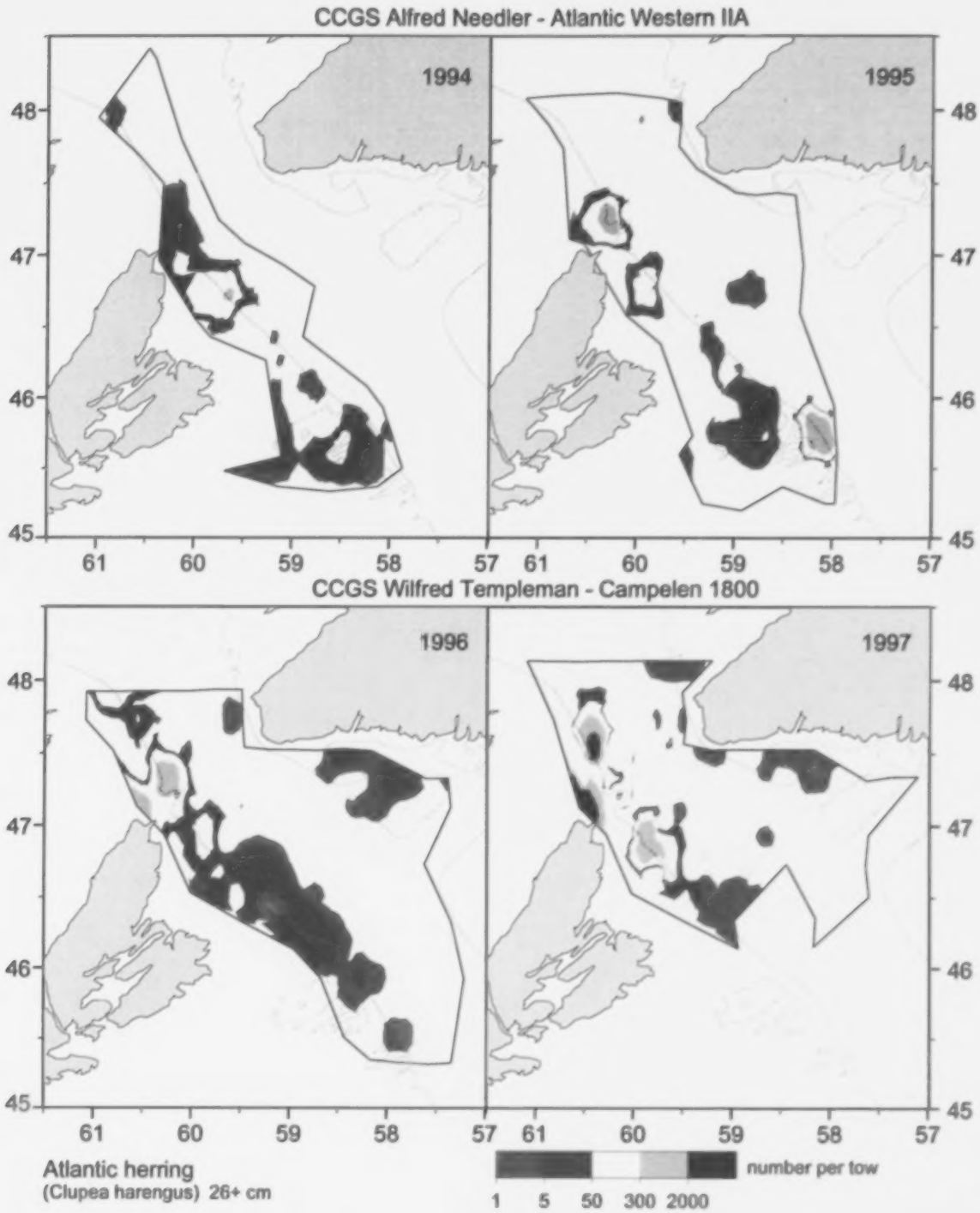

Figure 11d: Distribution of Atlantic herring (*Clupea harengus*) catches (number per tow) of fish 26 cm and larger during January surveys conducted in Cabot Strait, 1994 –1997.

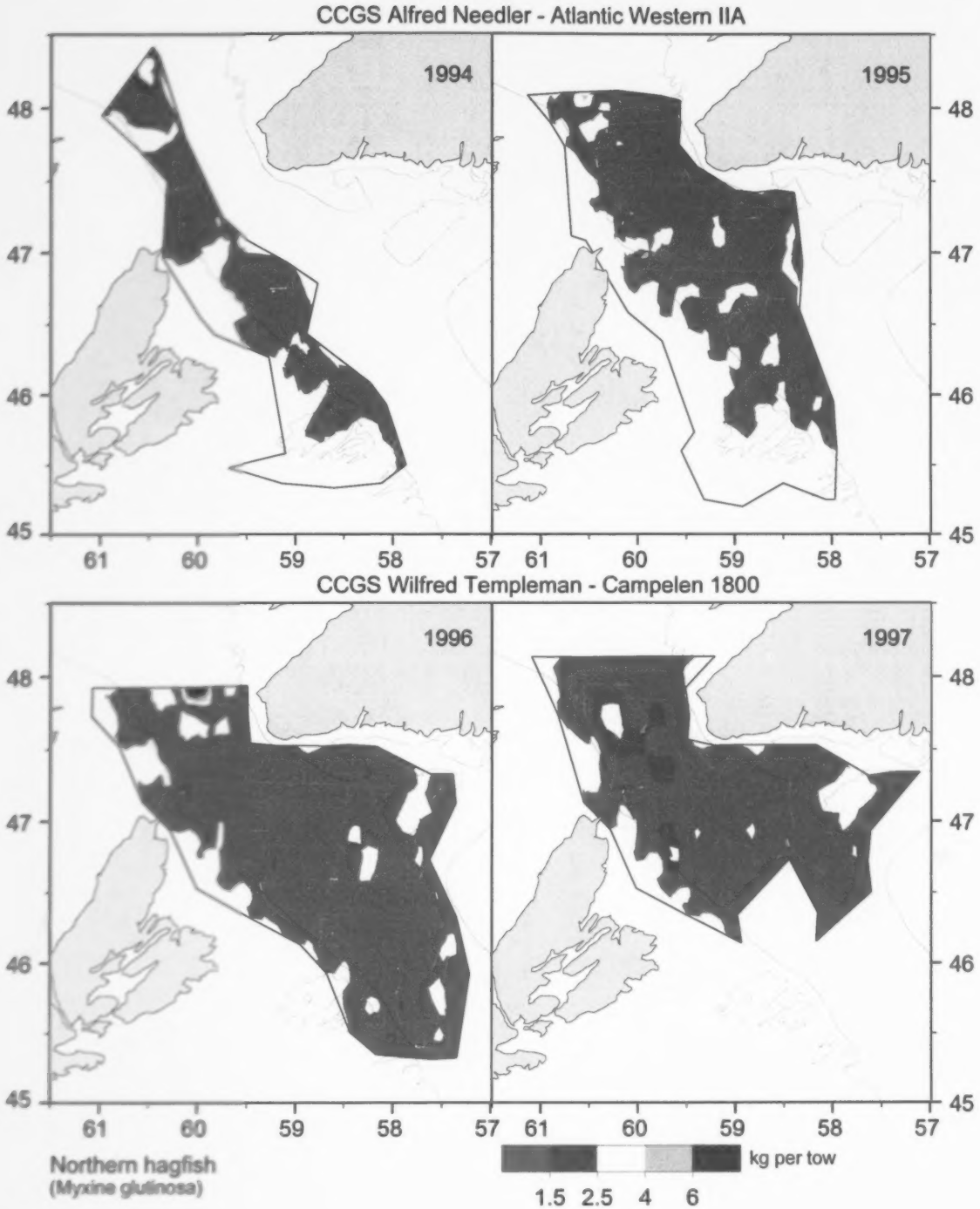

Figure 12a: Distribution of northern hagfish (*Myxine glutinosa*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

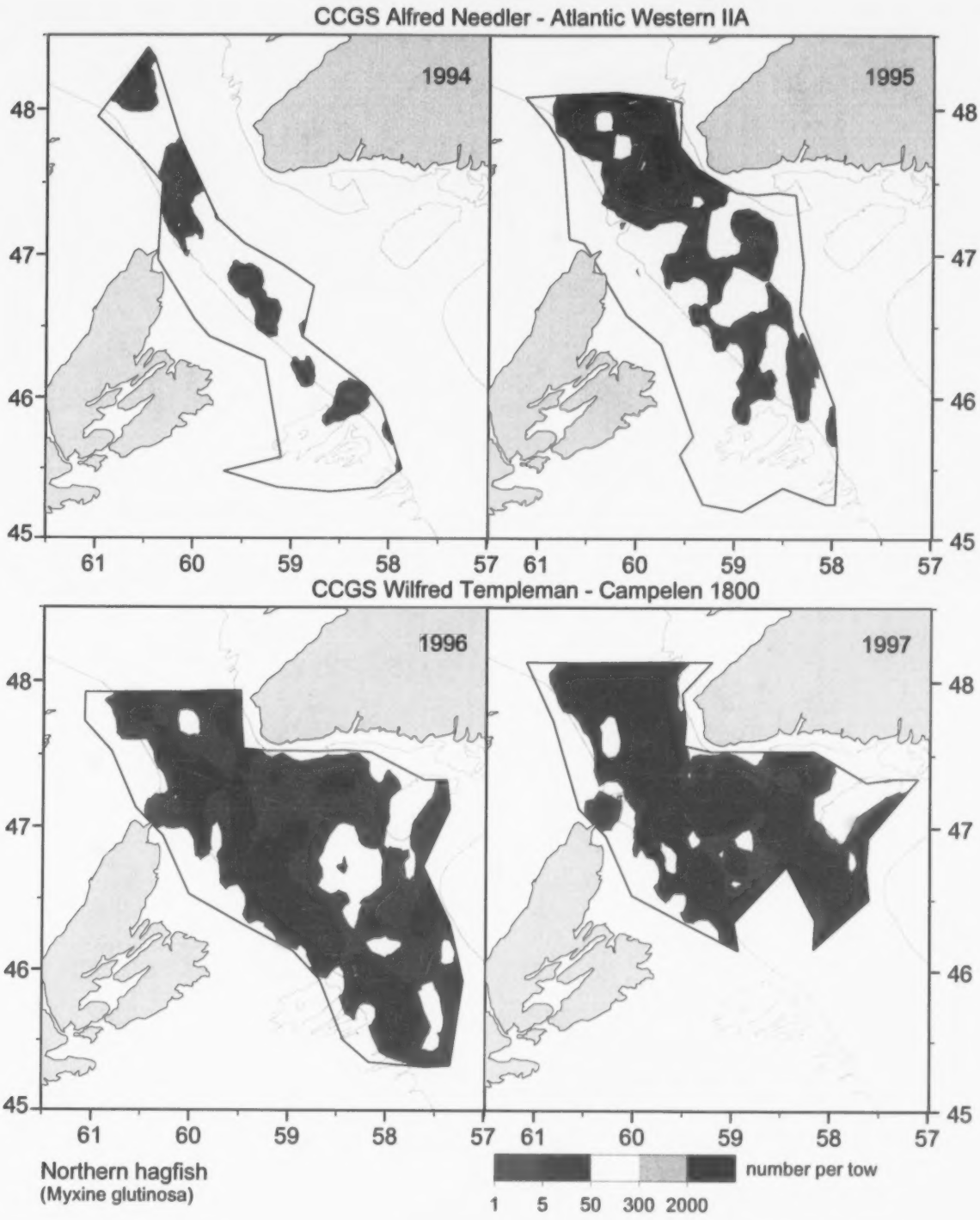

Figure 12b: Distribution of northern hagfish (*Myxine glutinosa*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

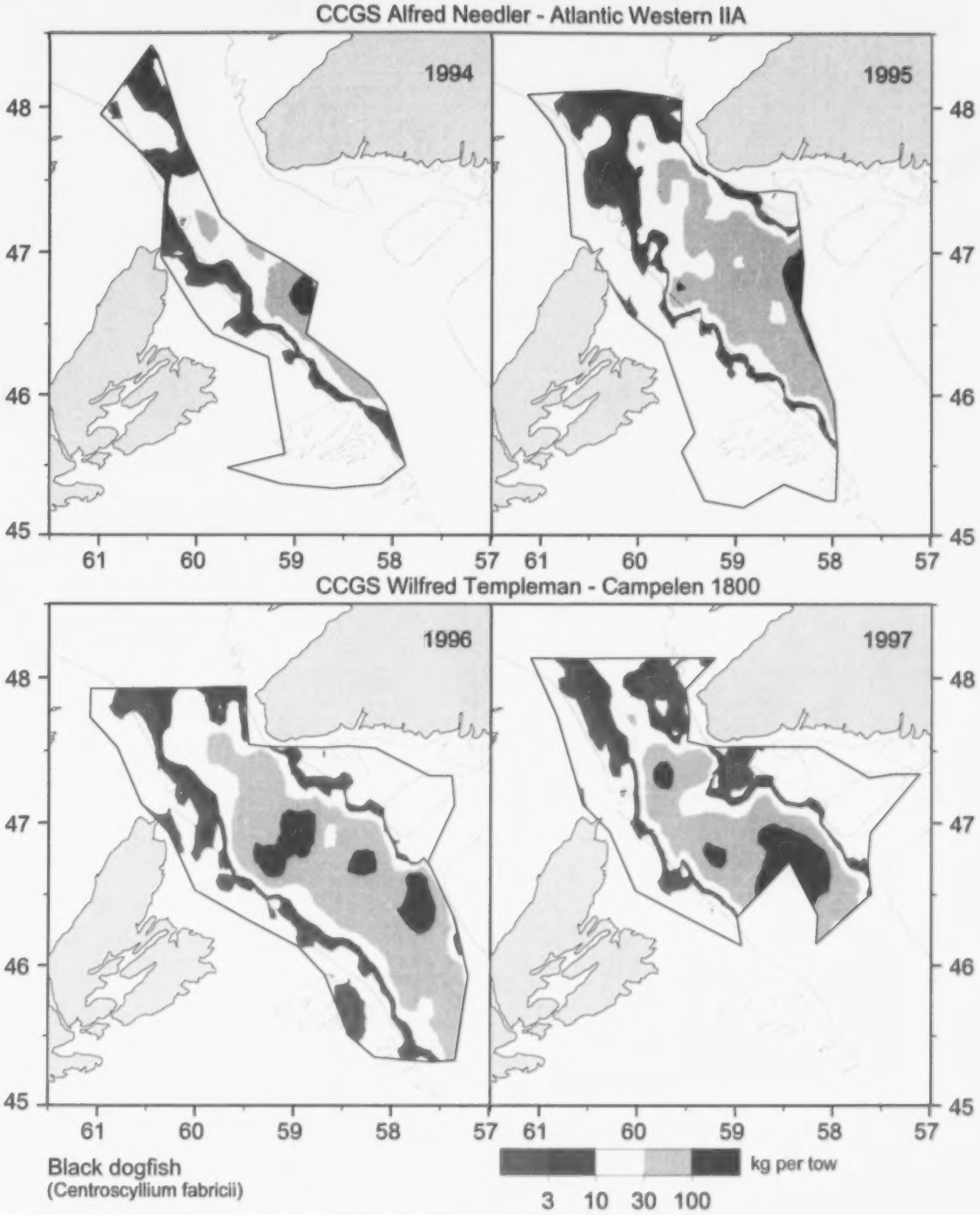

Figure 13a: Distribution of black dogfish (*Centroscyllium fabricii)* catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

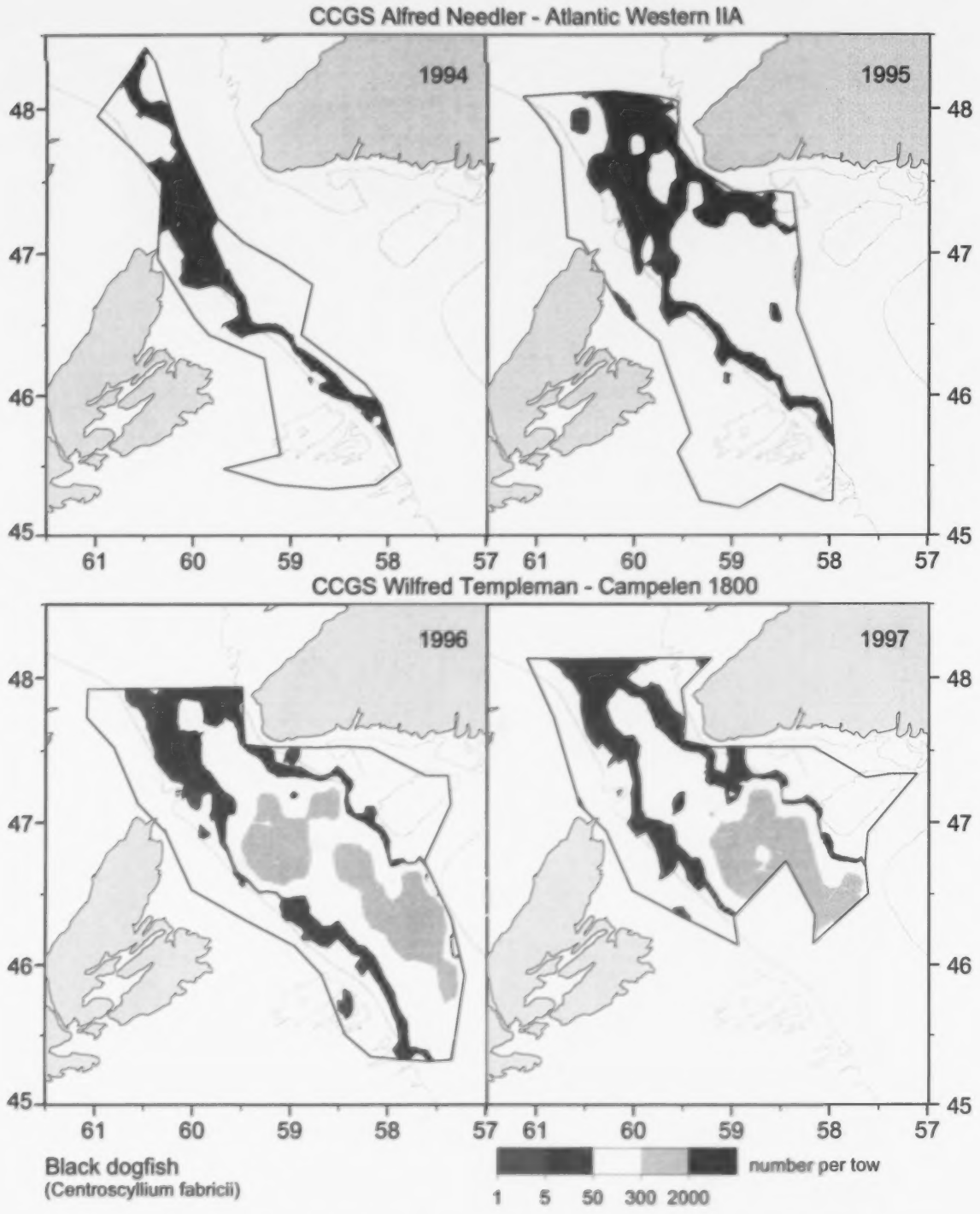

Figure 13b: Distribution of black dogfish (*Centroscyllium fabricii)* catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

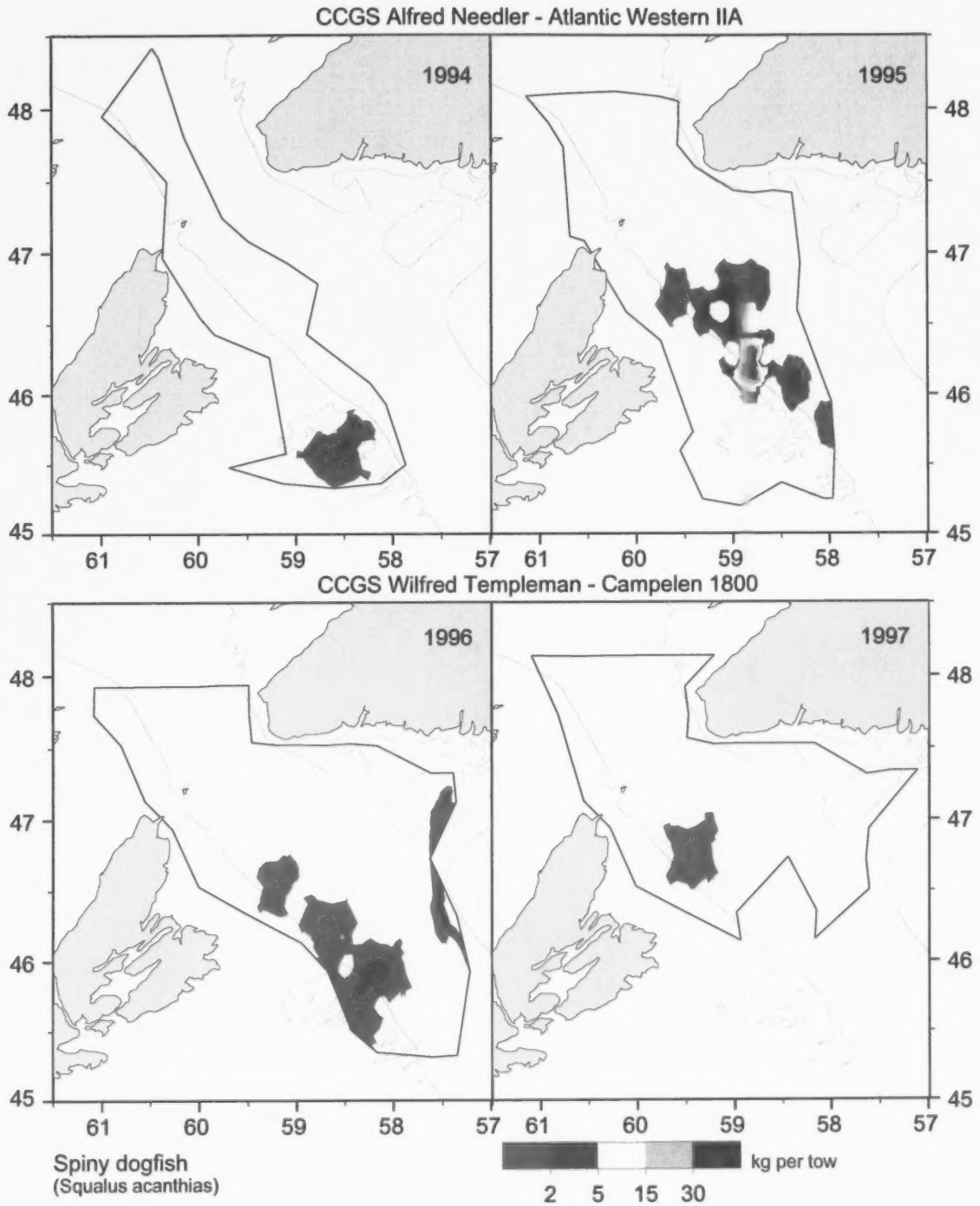

Figure 14a: Distribution of spiny dogfish (*Squalus acanthias*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

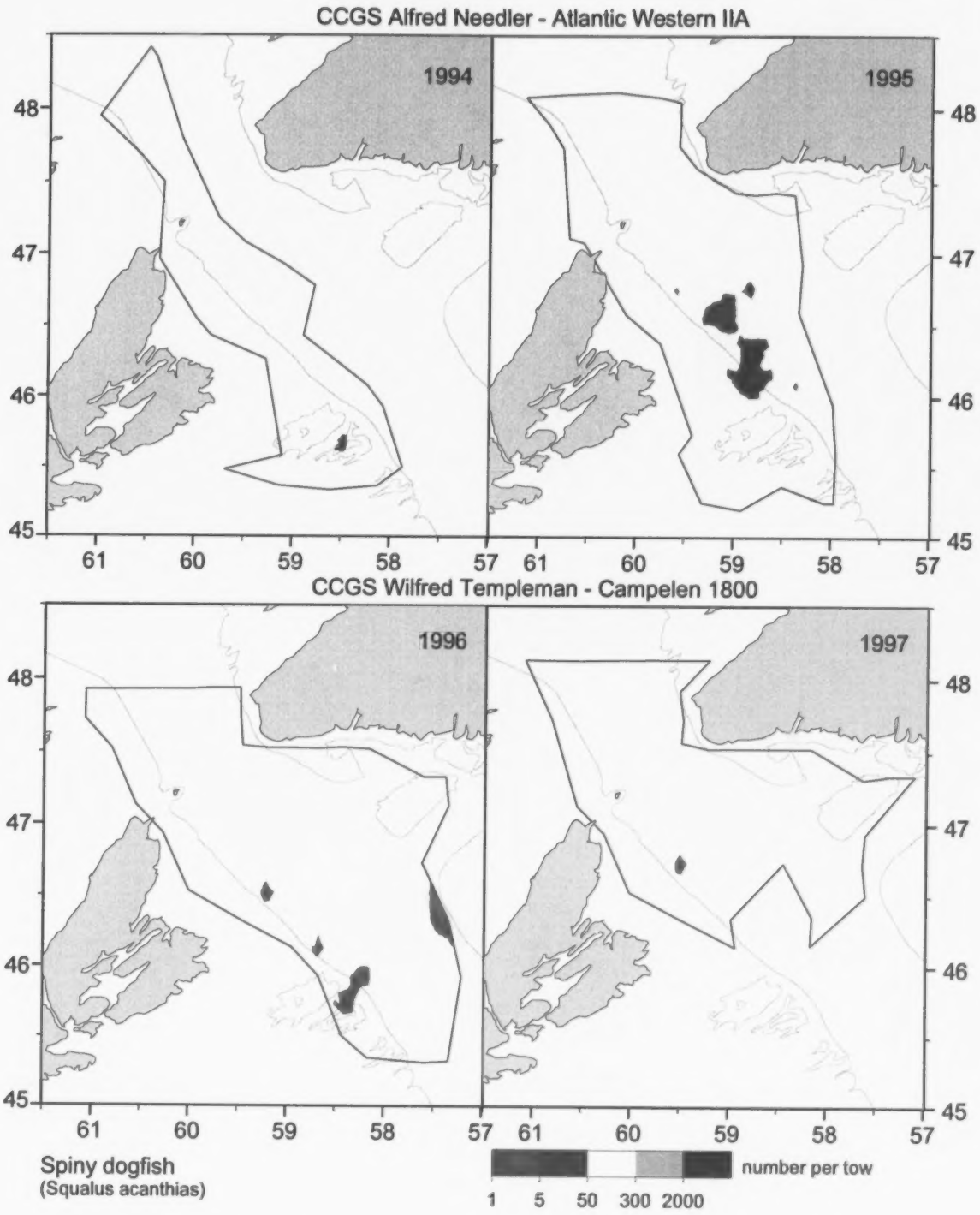

Figure 14b: Distribution of spiny dogfish (*Squalus acanthias*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

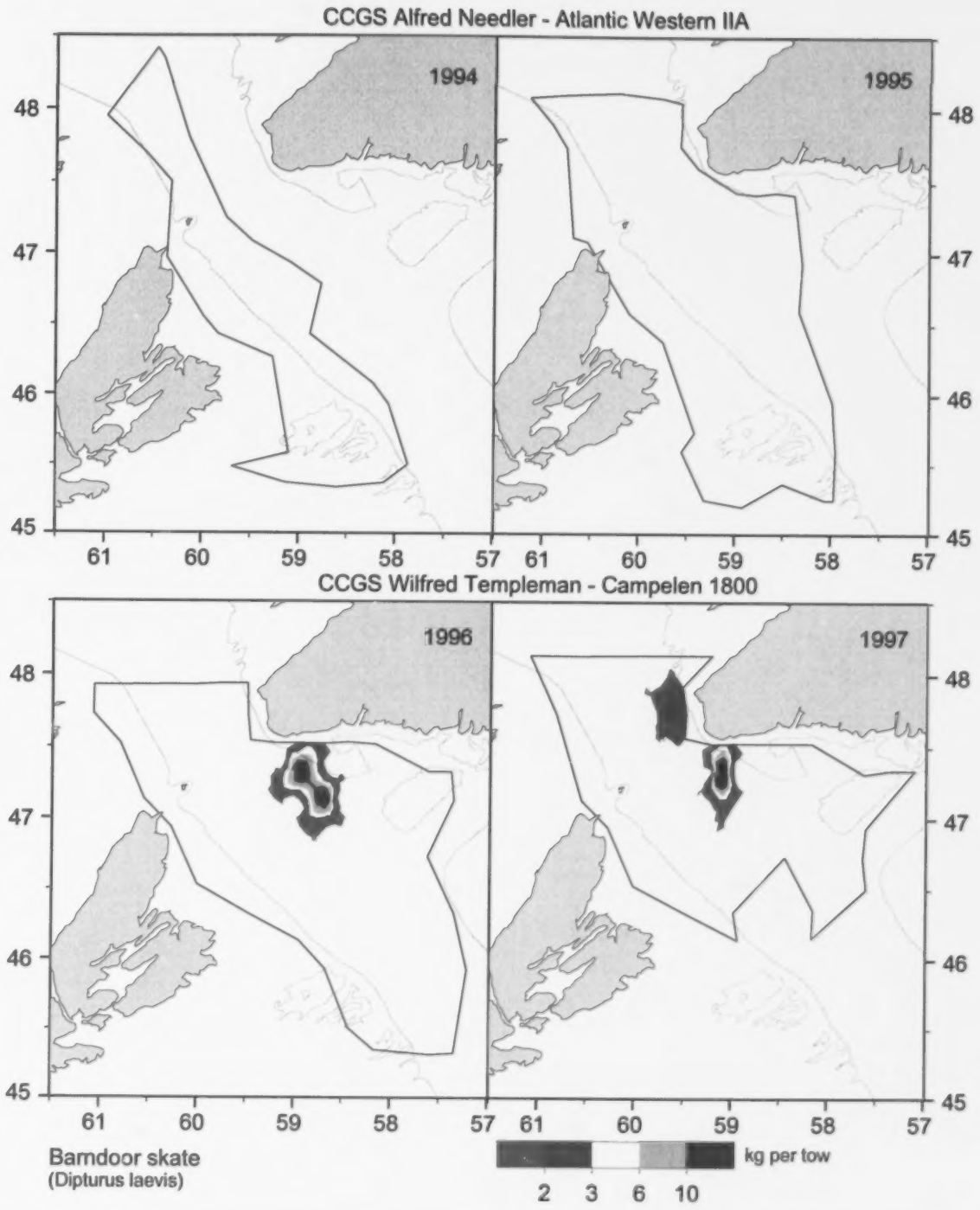

Figure 15a: Distribution of barndoor skate (*Dipturus laevis*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

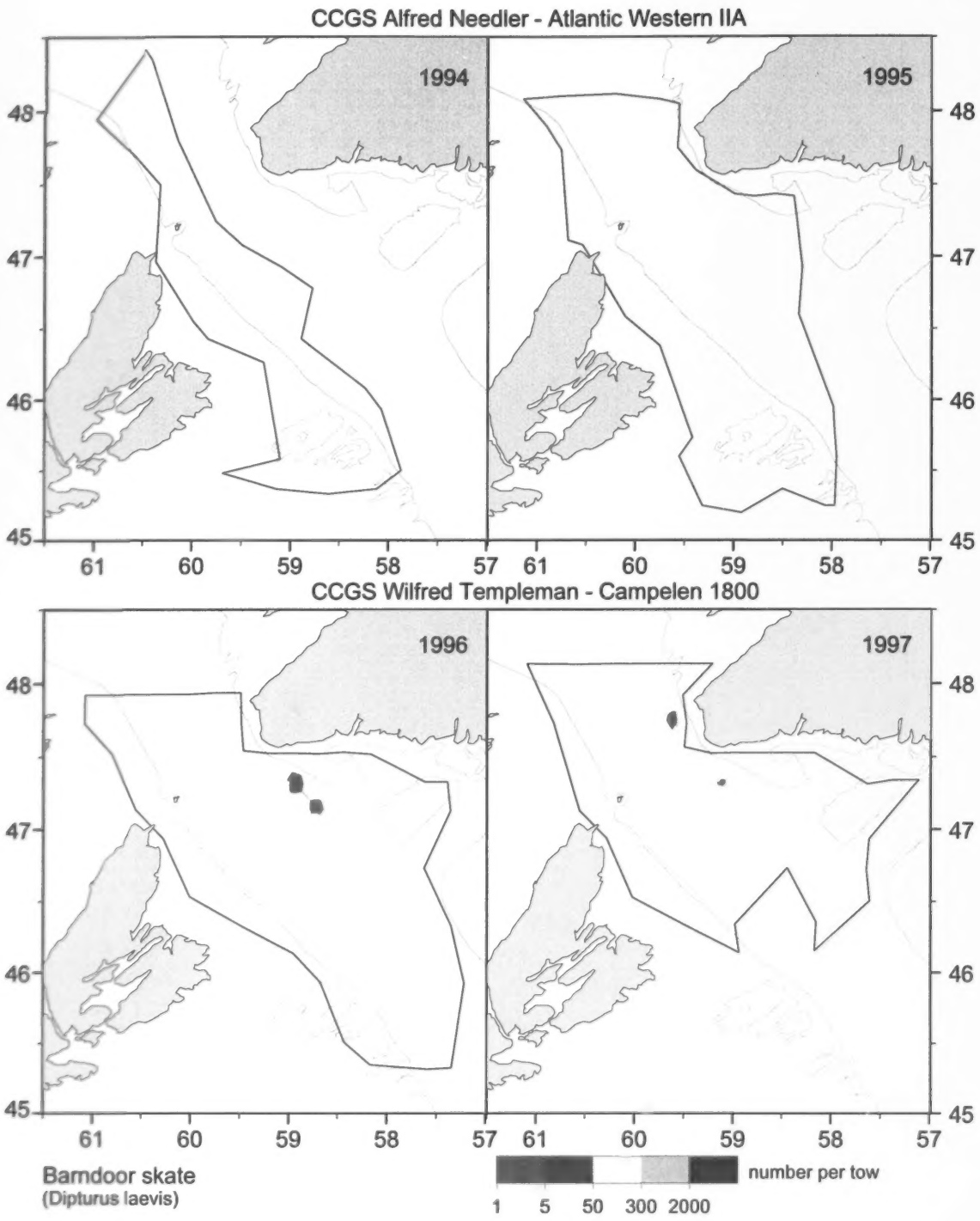

Figure 15b: Distribution of barndoor skate (*Dipturus laevis*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

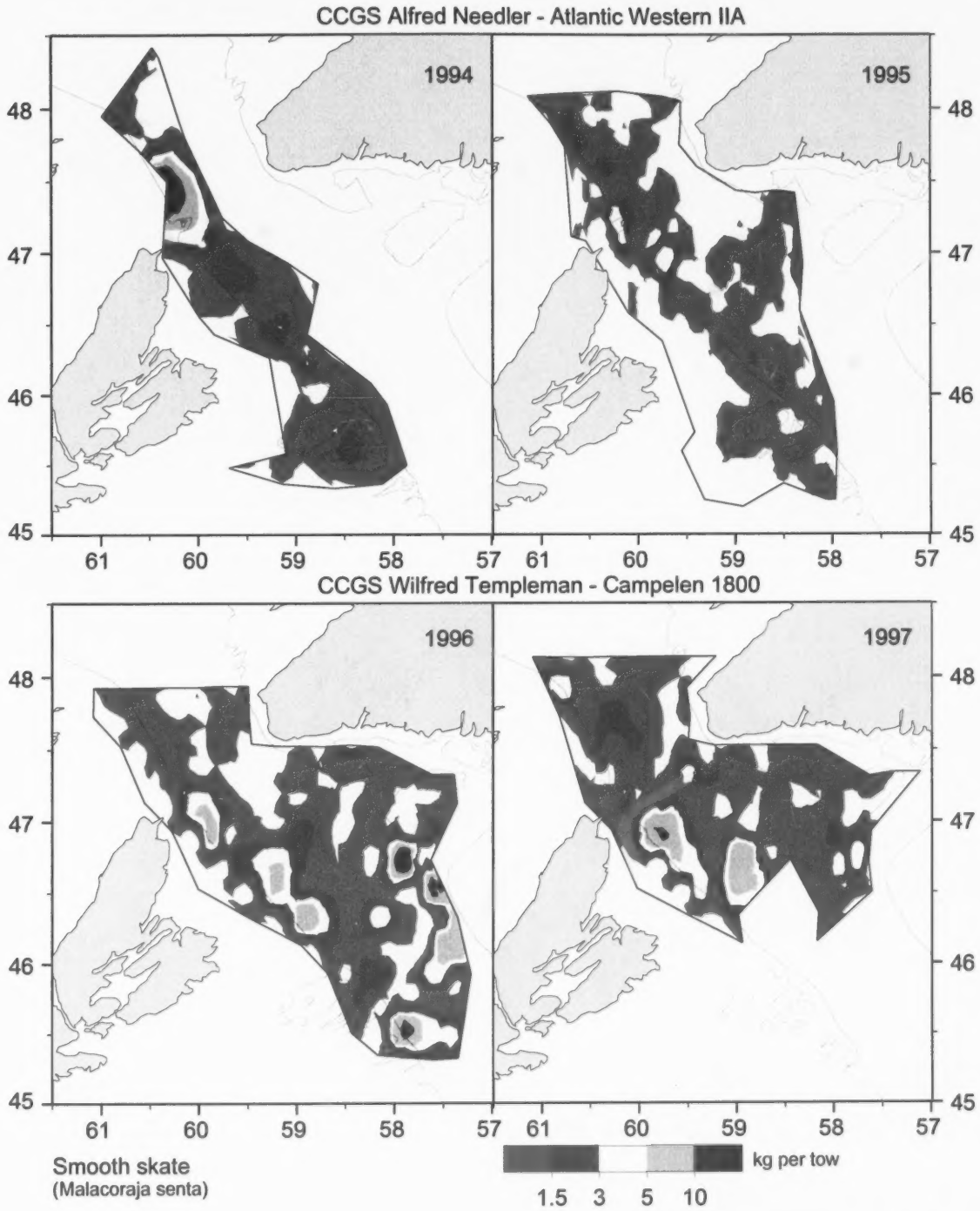

Figure 16a: Distribution of smooth skate (*Malacoraja senta*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

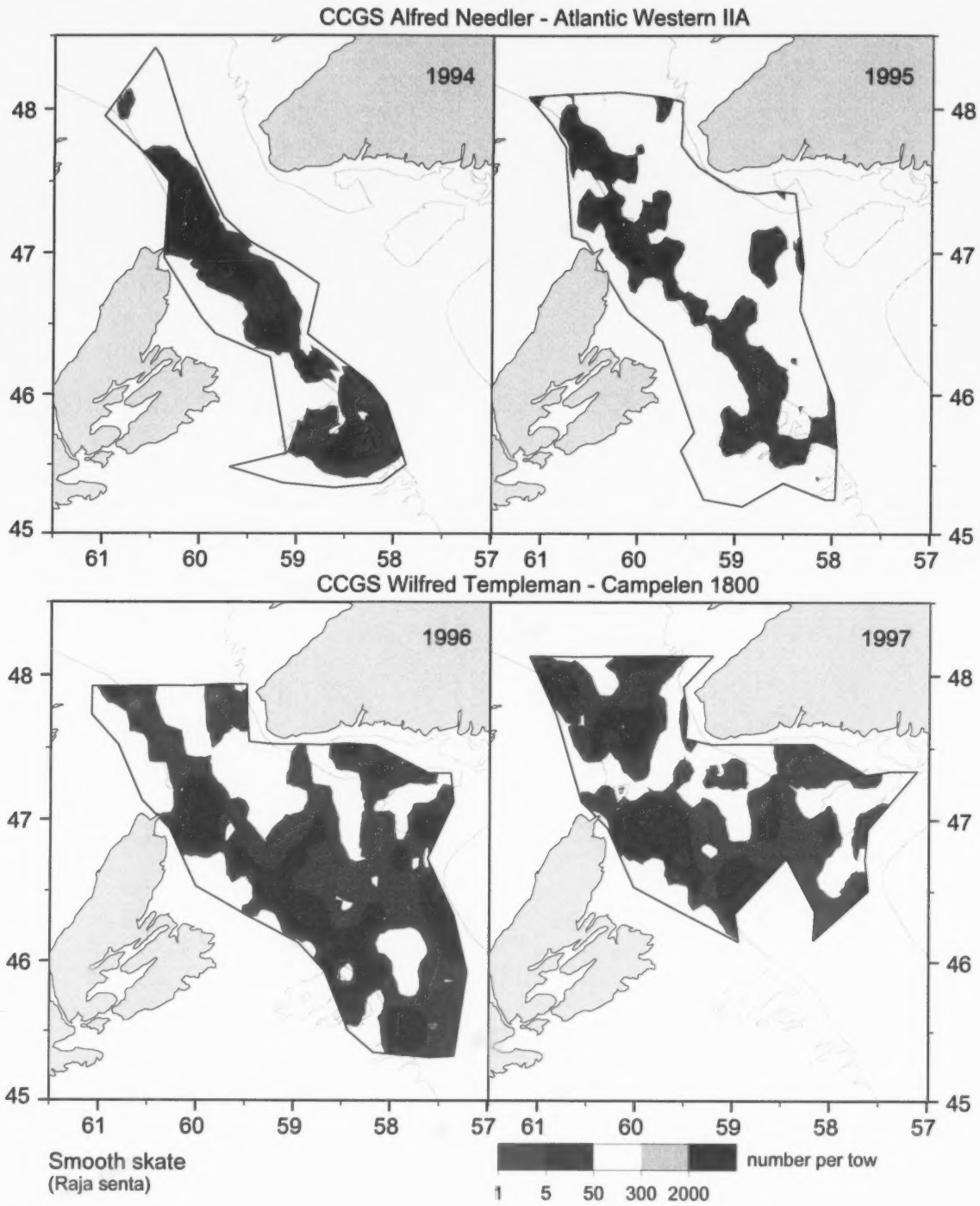

Figure 16b: Distribution of smooth skate (*Malacoraja senta*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

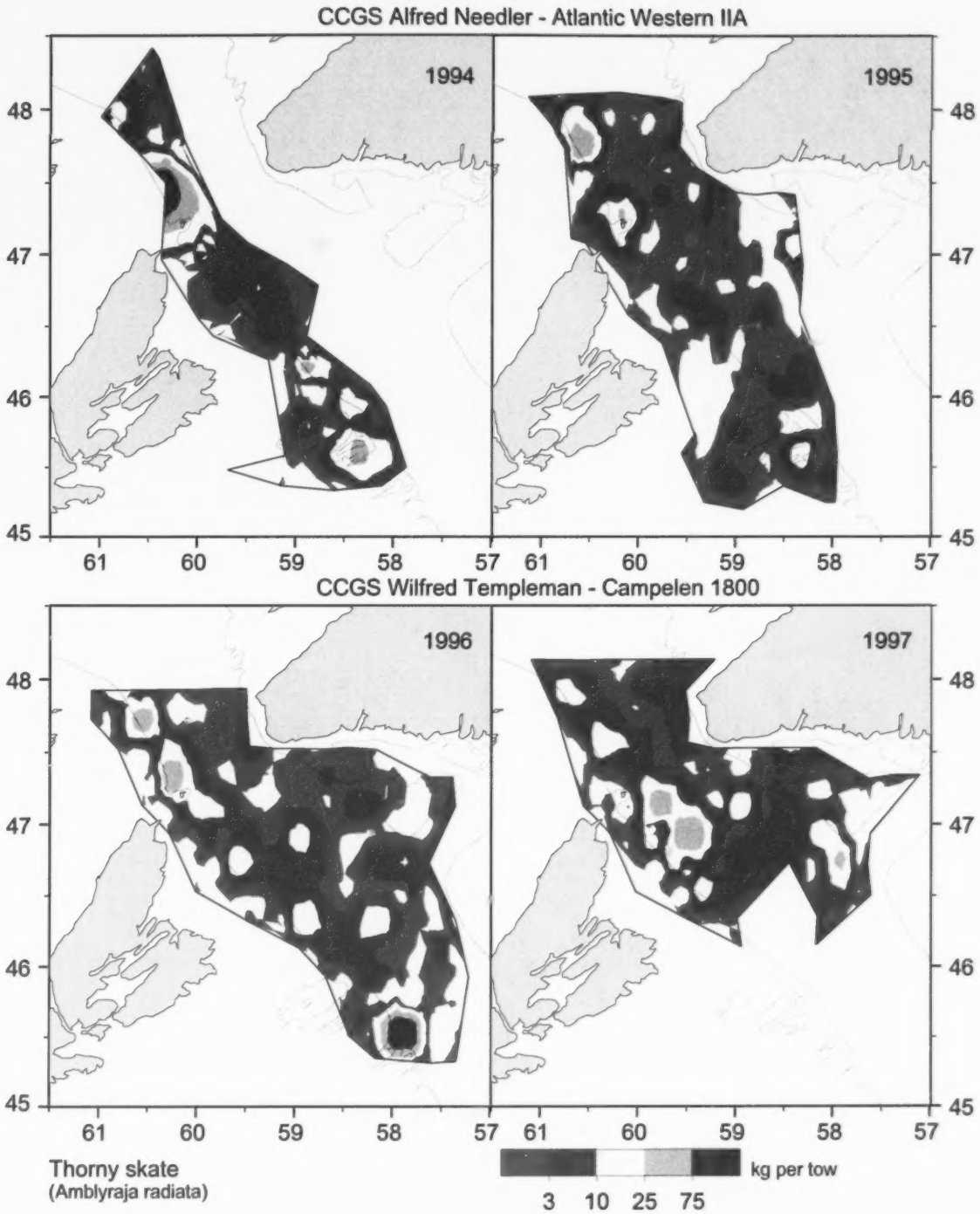

Figure 17a: Distribution of thorny skate (*Amblyraja radiata*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

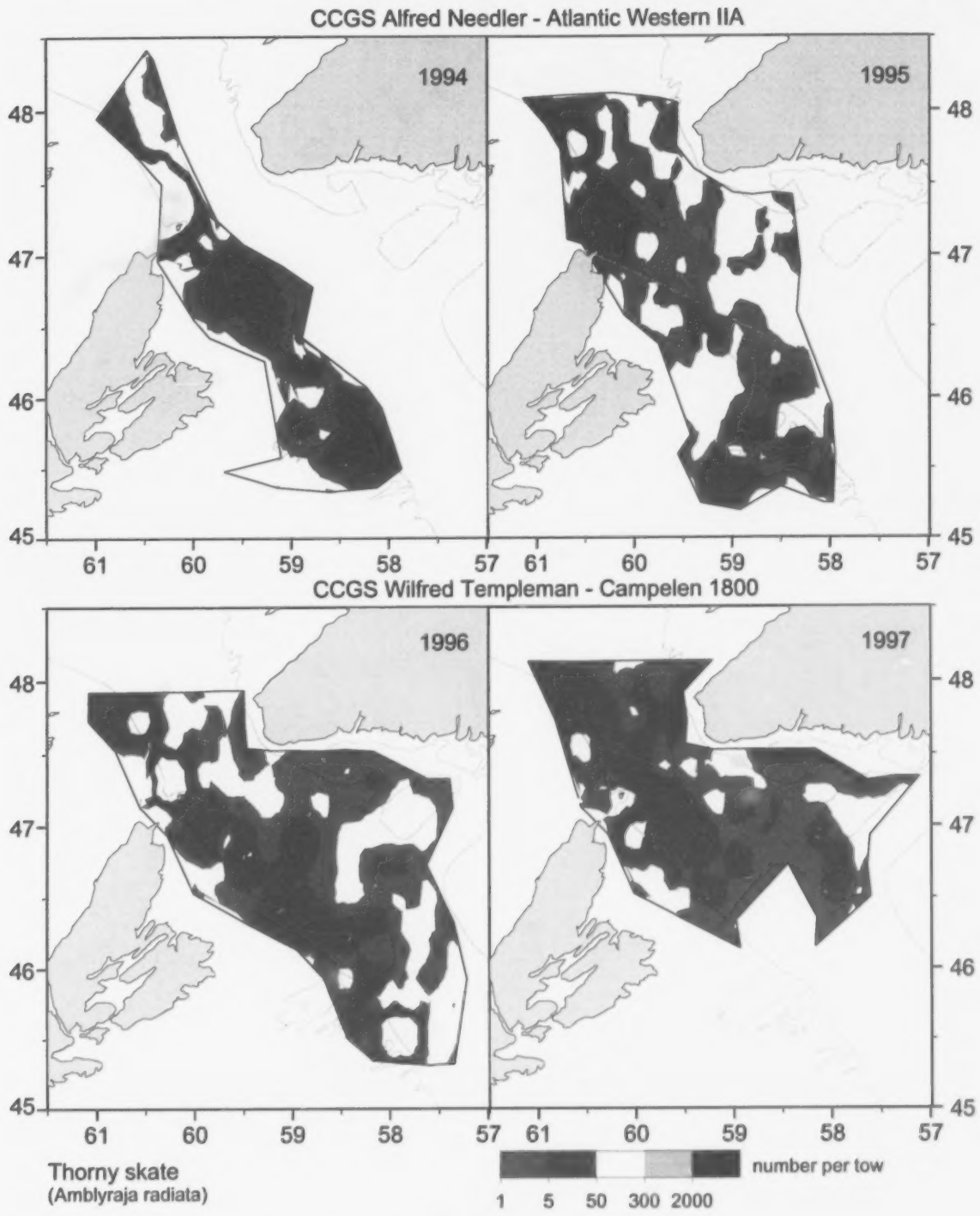

Figure 17b: Distribution of thorny skate (*Amblyraja radiata*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

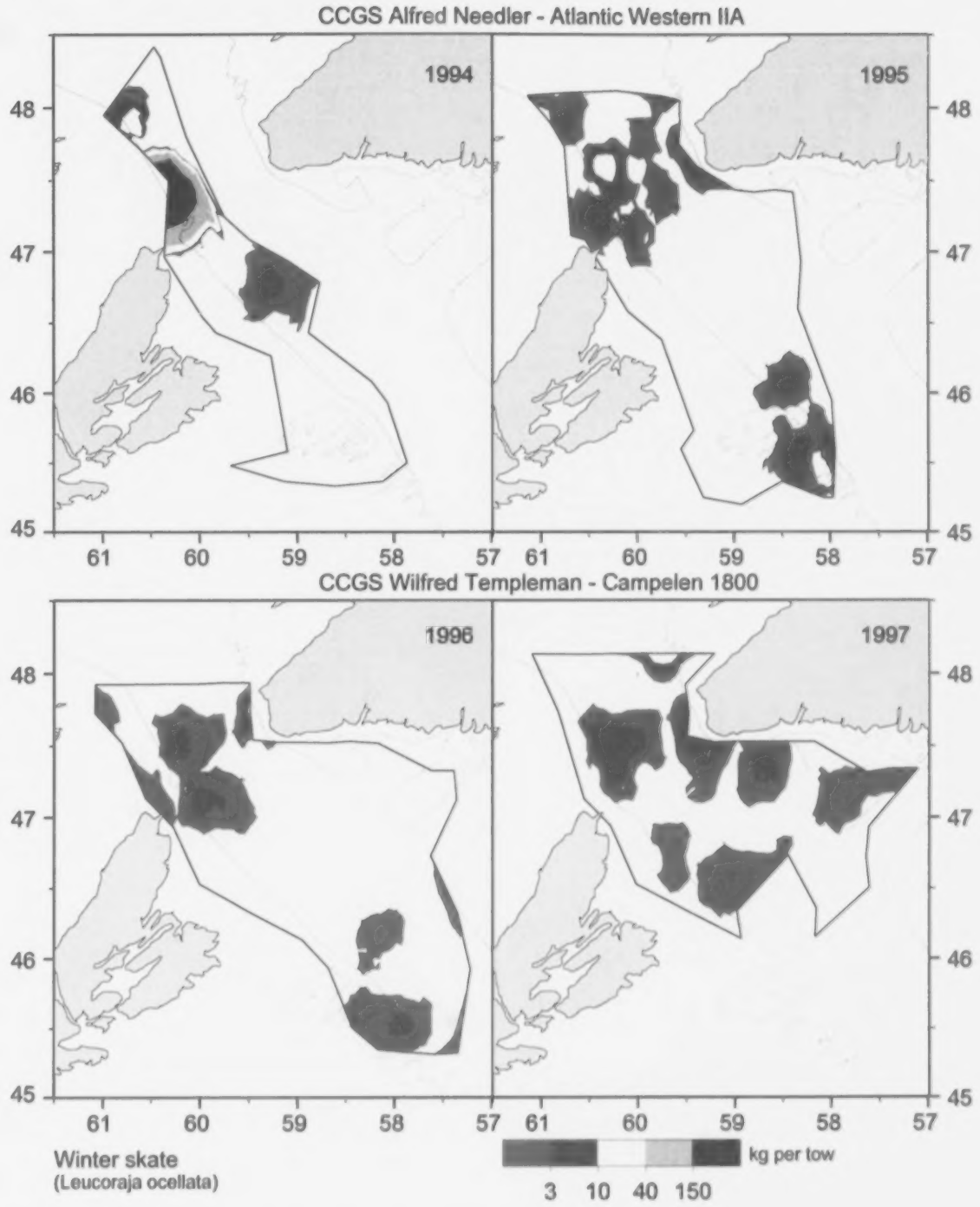

Figure 18a: Distribution of winter skate (*Leucoraja ocellata*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

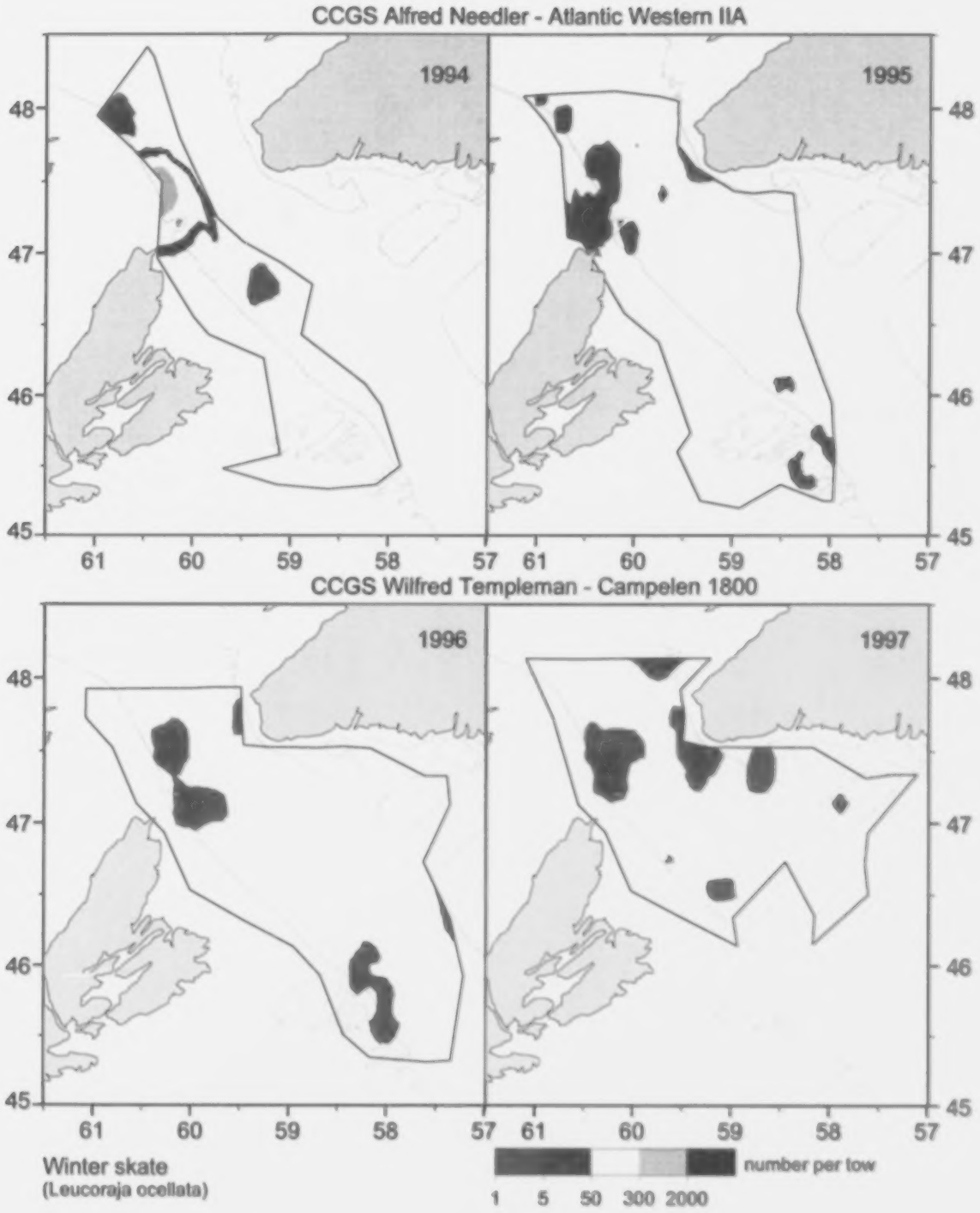

Figure 18b: Distribution of winter skate (*Leucoraja ocellata*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

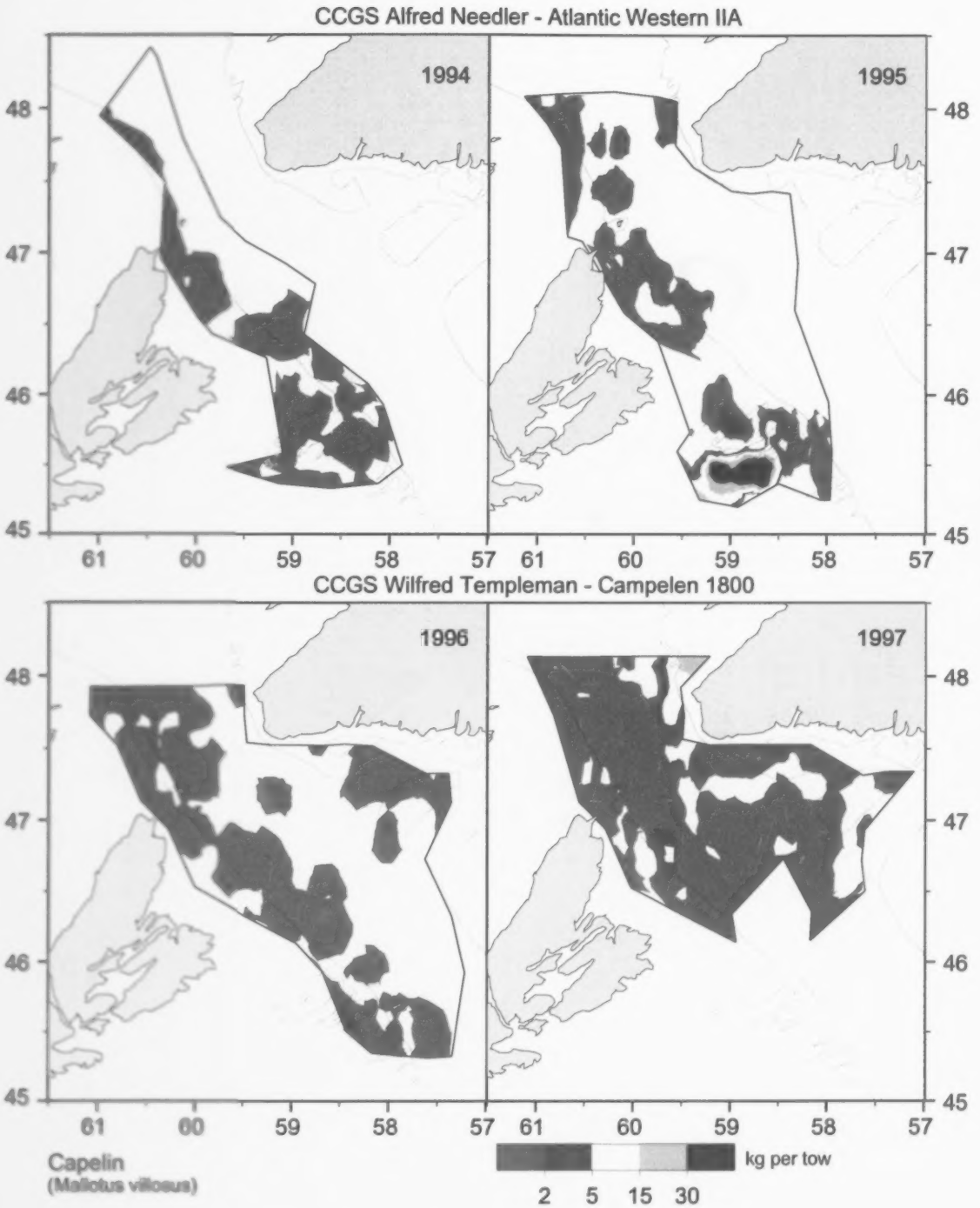

Figure 19a: Distribution of capelin (*Mallotus villosus*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

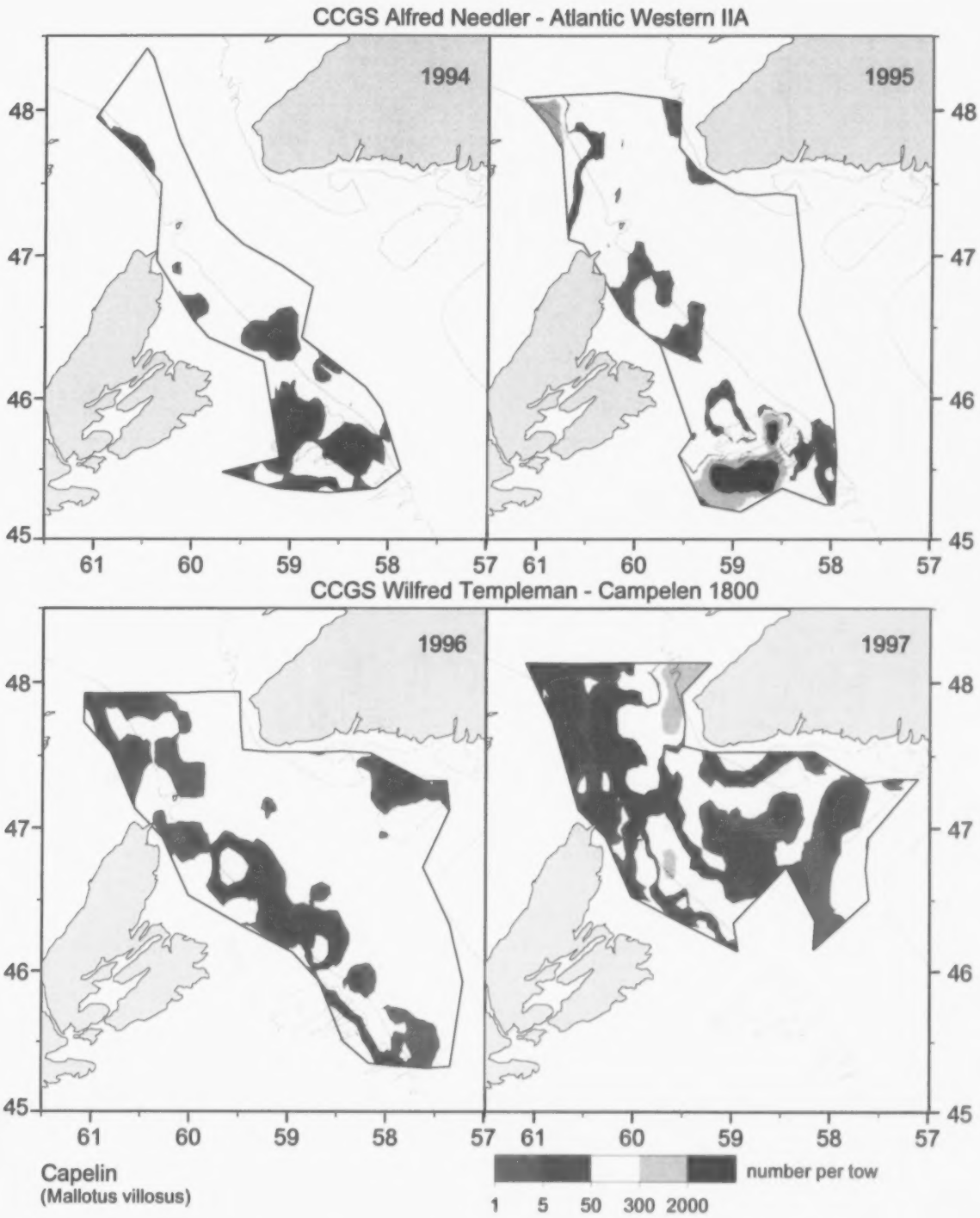

Figure 19b: Distribution of capelin (*Mallotus villosus*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

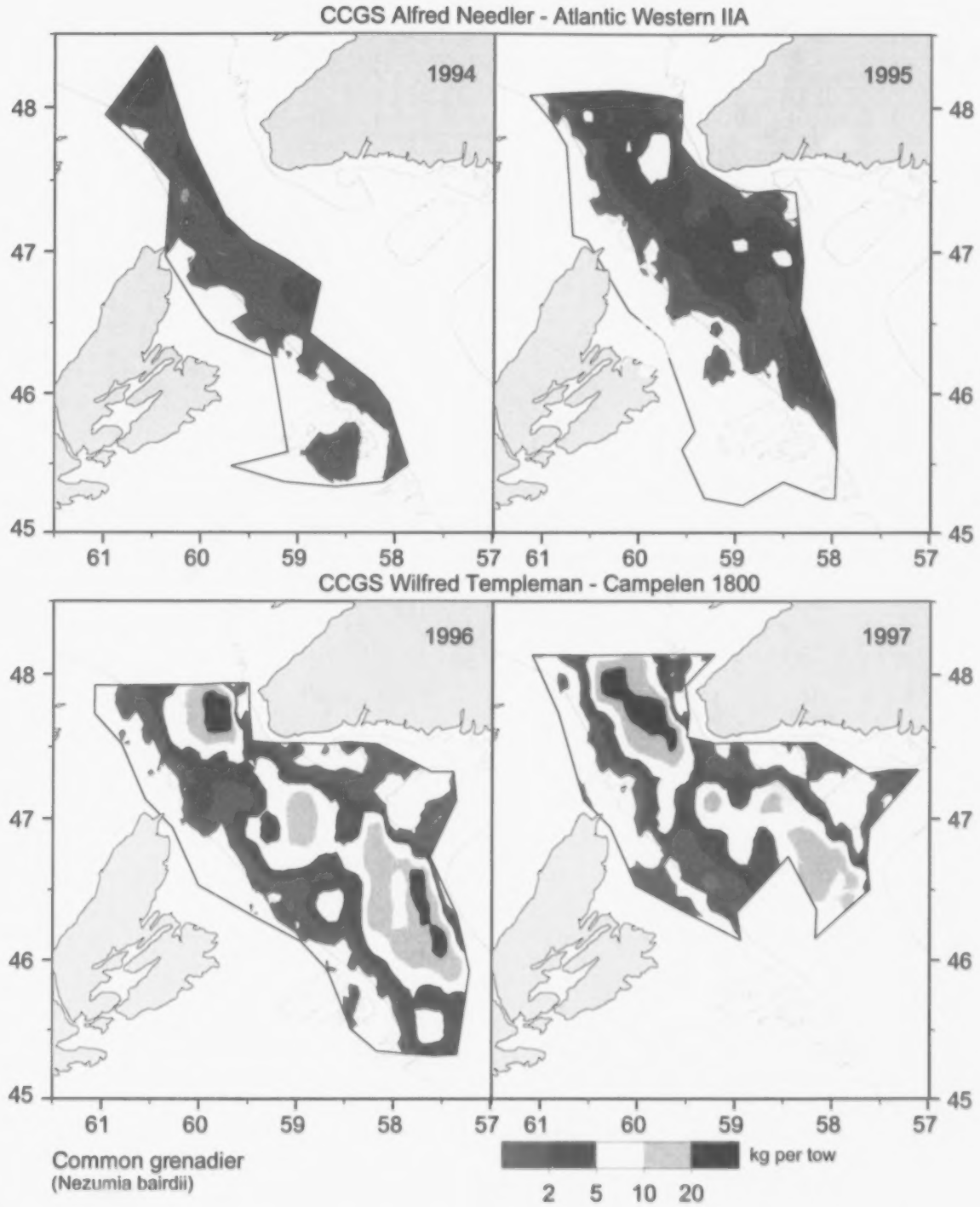

Figure 20a: Distribution of common grenadier (*Nezumia bairdii*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

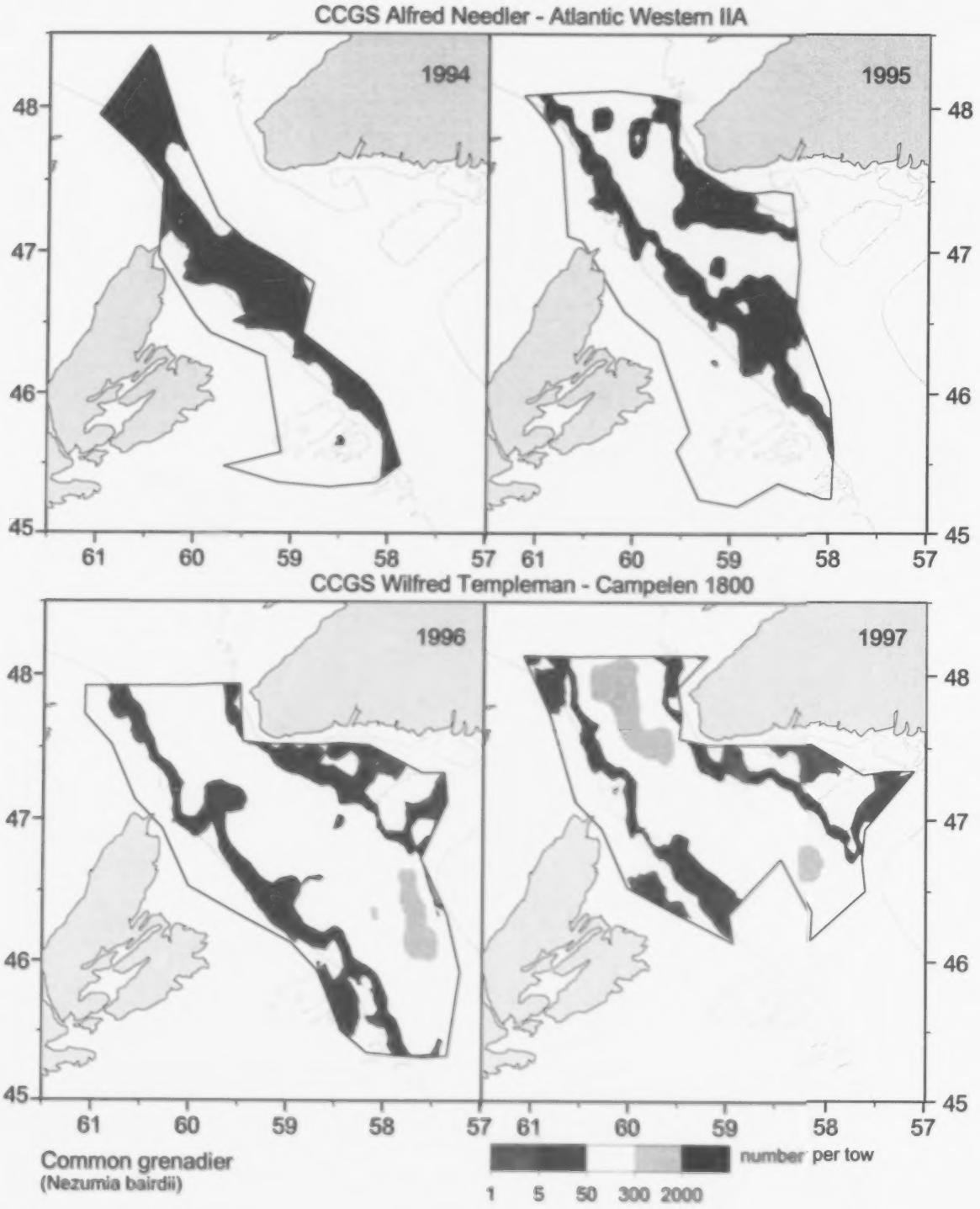

Figure 20b: Distribution of common grenadier (*Nezumia bairdii*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

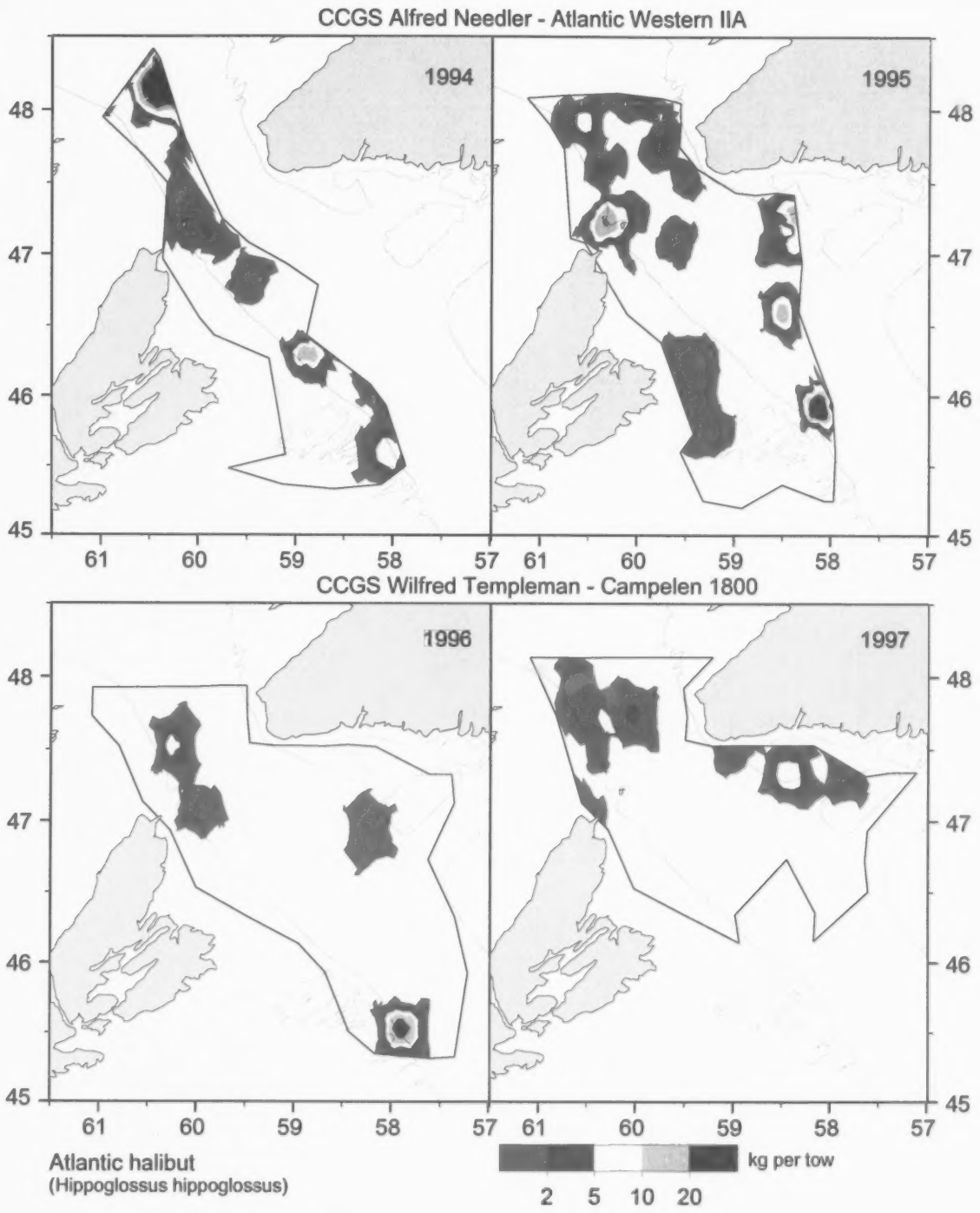

Figure 21a: Distribution of Atlantic halibut (*Hippoglossus hippoglossus*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

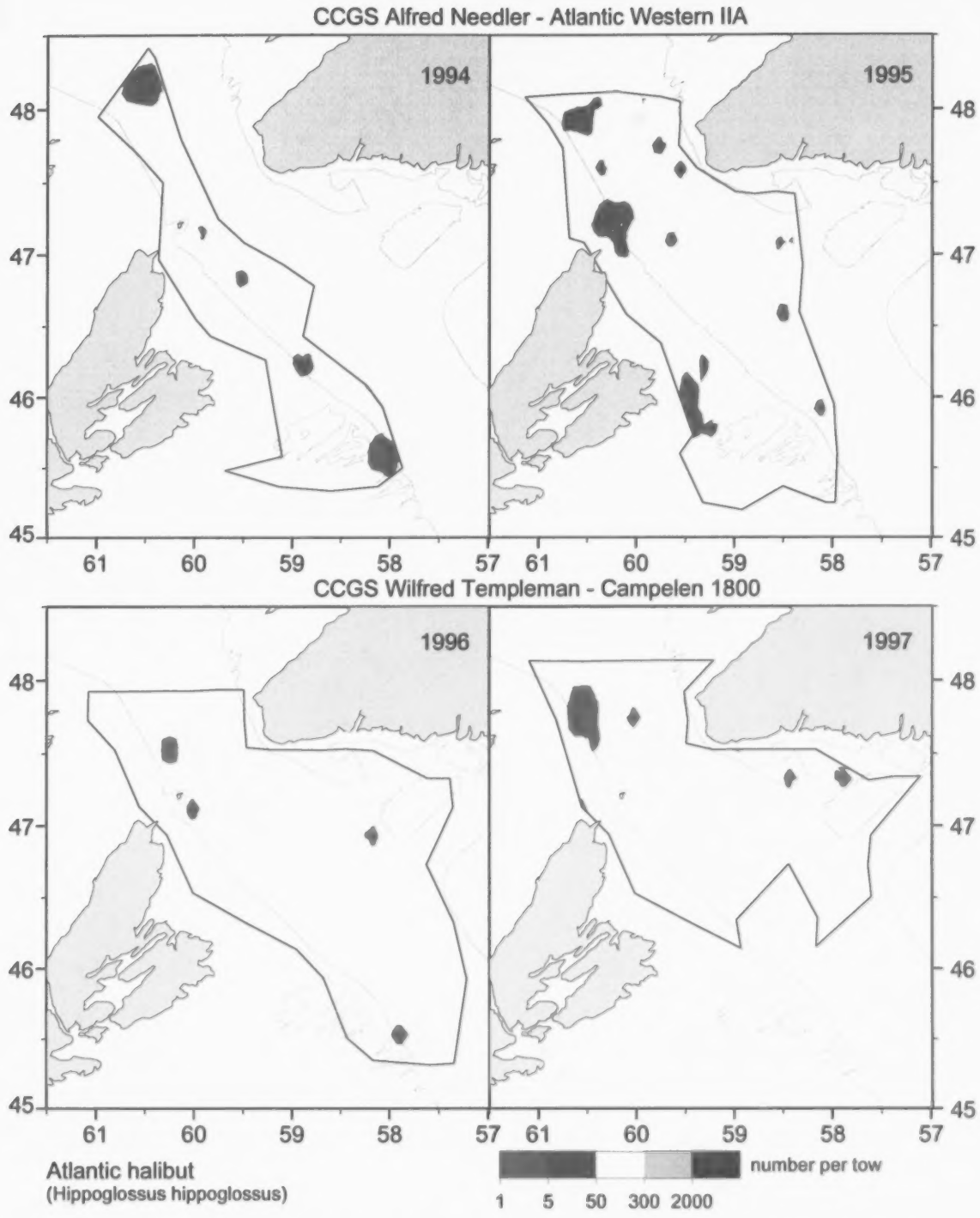

Figure 21b: Distribution of Atlantic halibut (*Hippoglossus hippoglossus*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

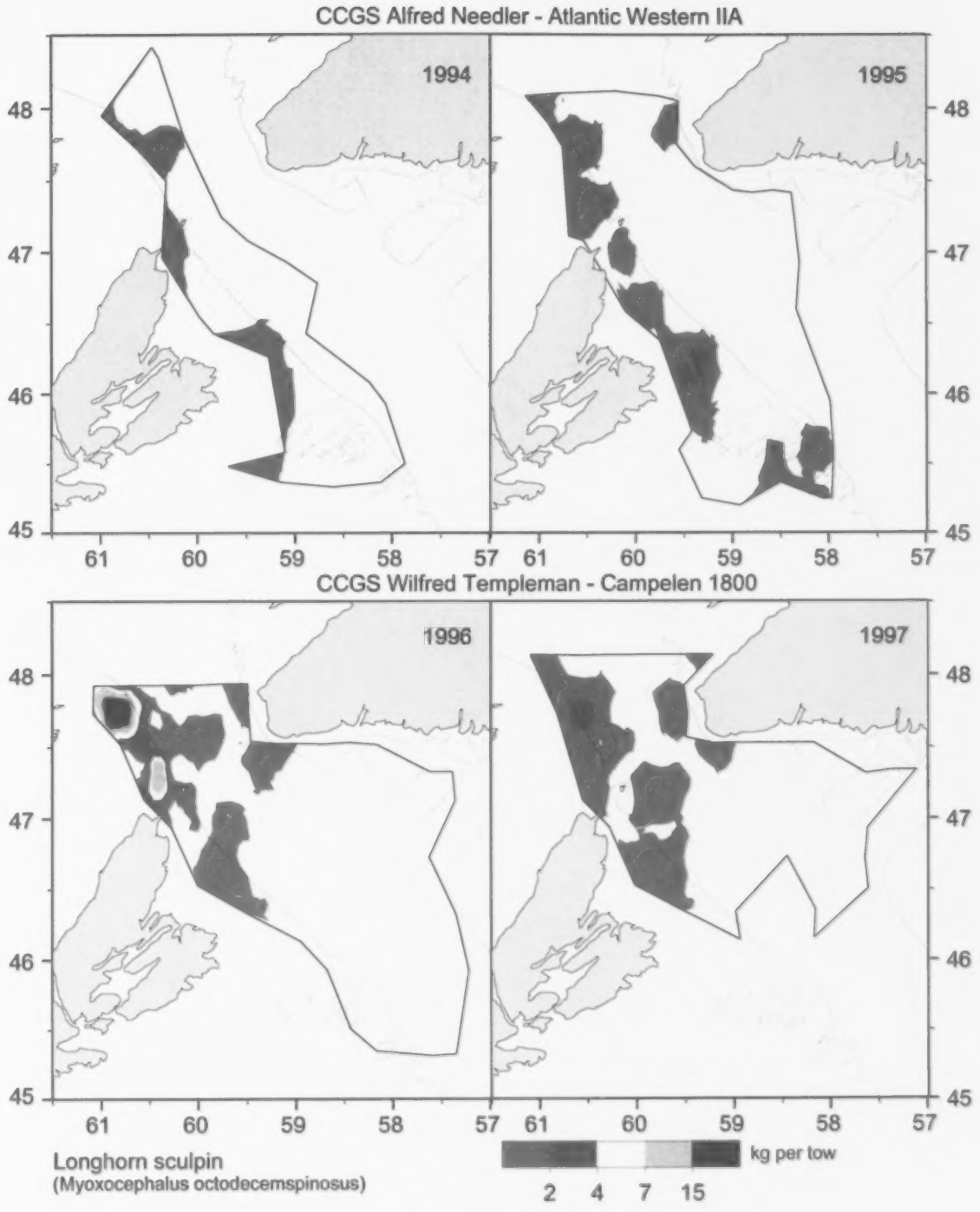

Figure 22a: Distribution of longhorn sculpin (*Myoxocephalus octodecemspinosus*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

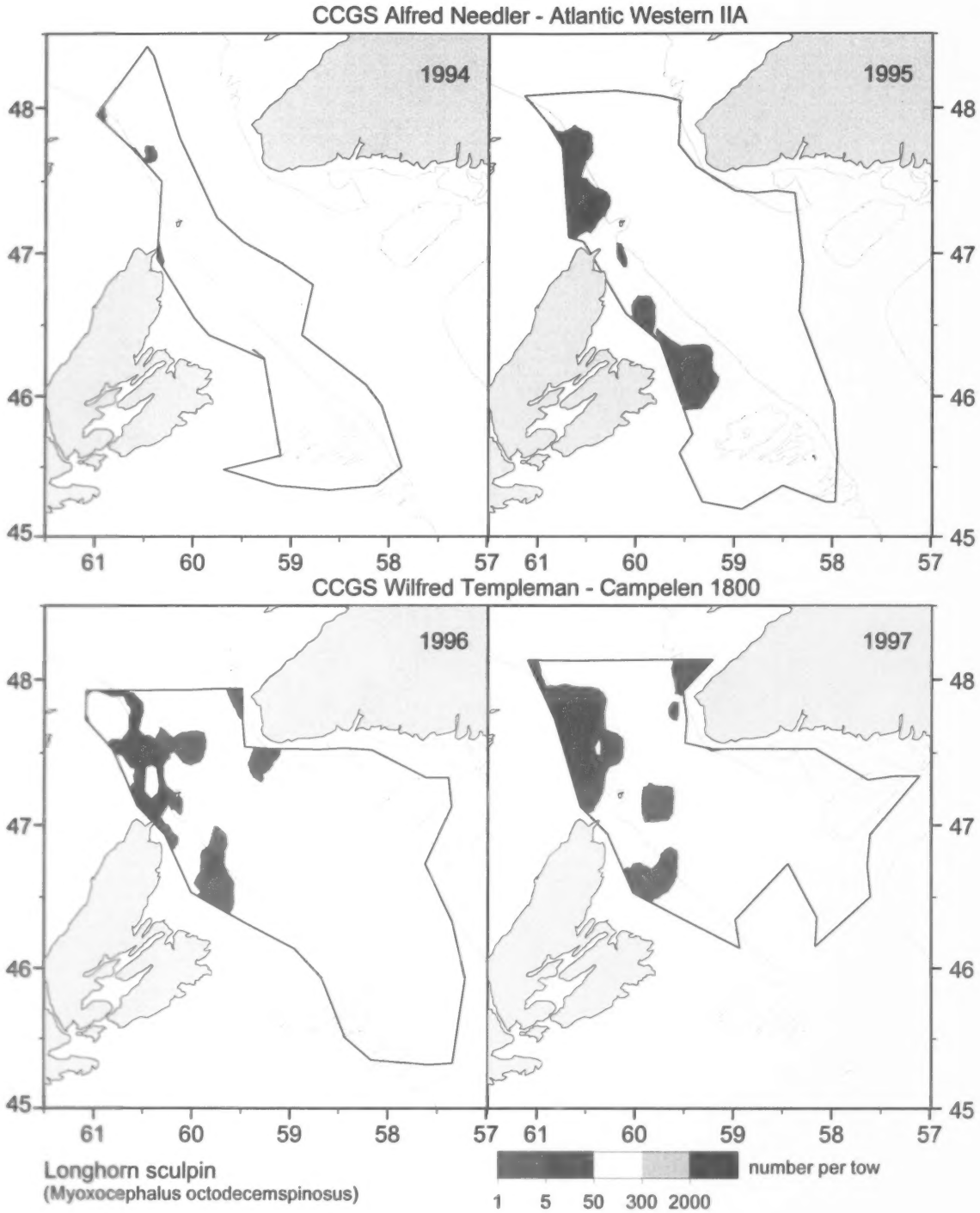

Figure 22b: Distribution of longhorn sculpin (*Myoxocephalus octodecemspinosus*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

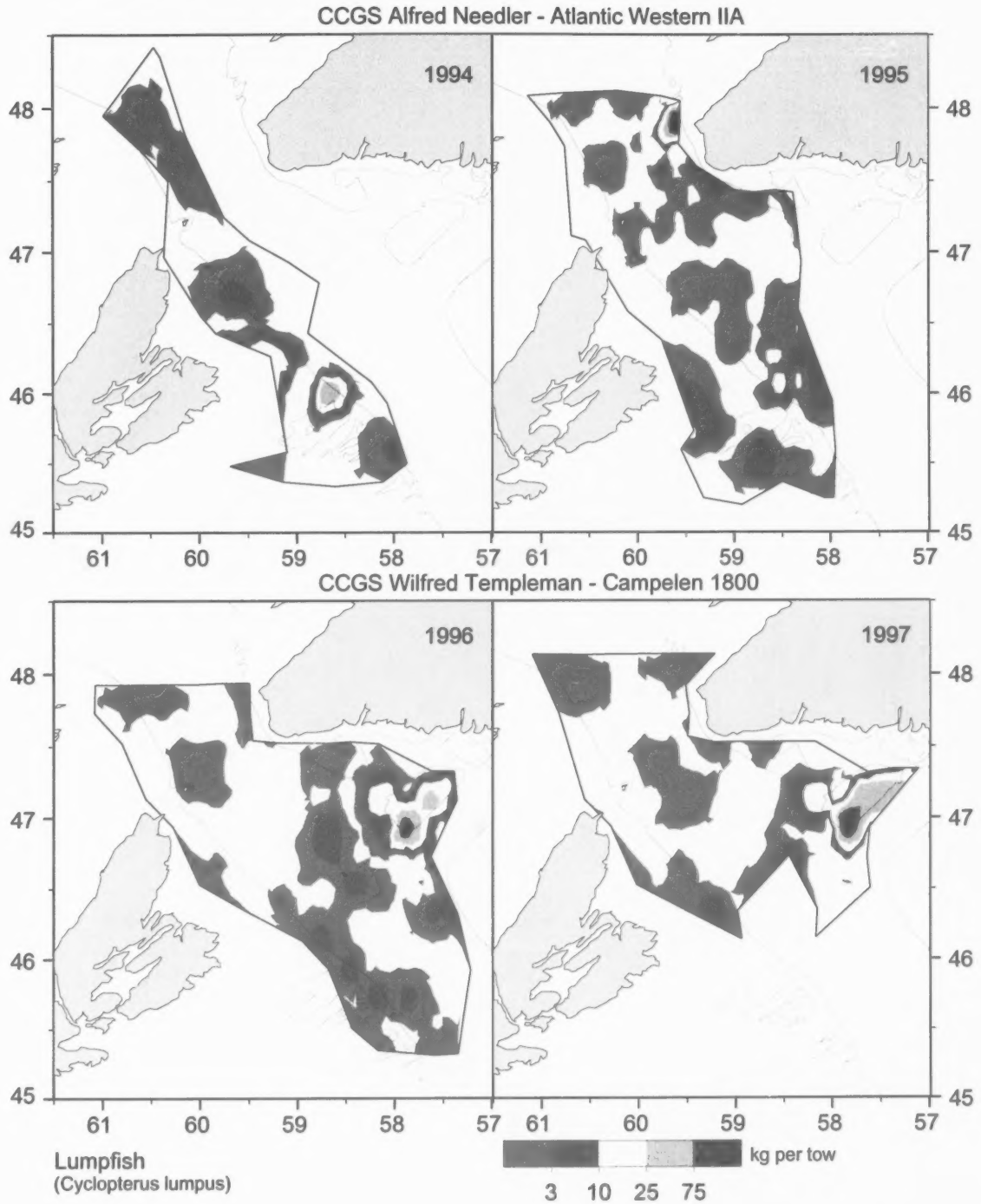

Figure 23a: Distribution of lumpfish (*Cyclopterus lumpus*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

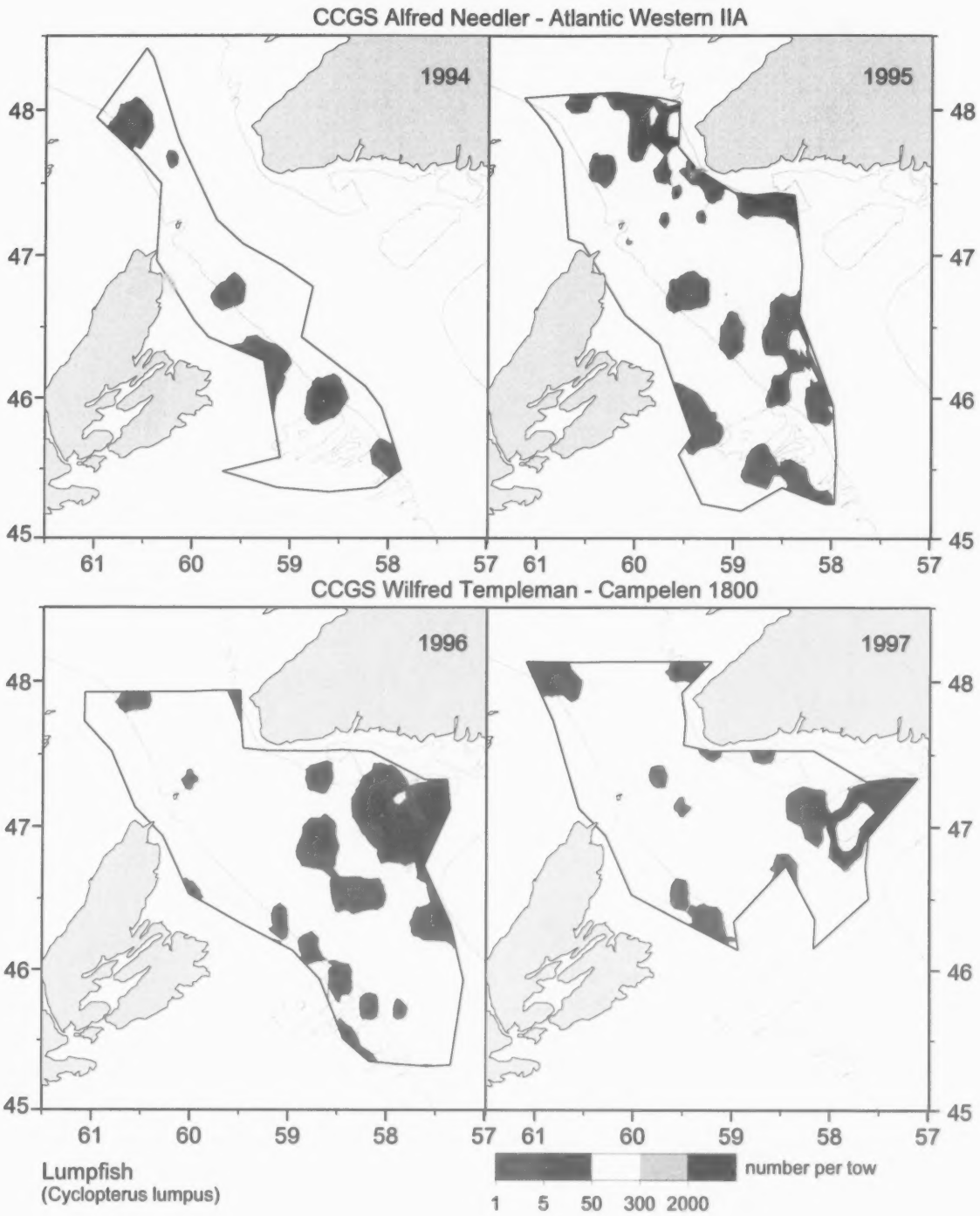

Figure 23b: Distribution of lumpfish (*Cyclopterus lumpus*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

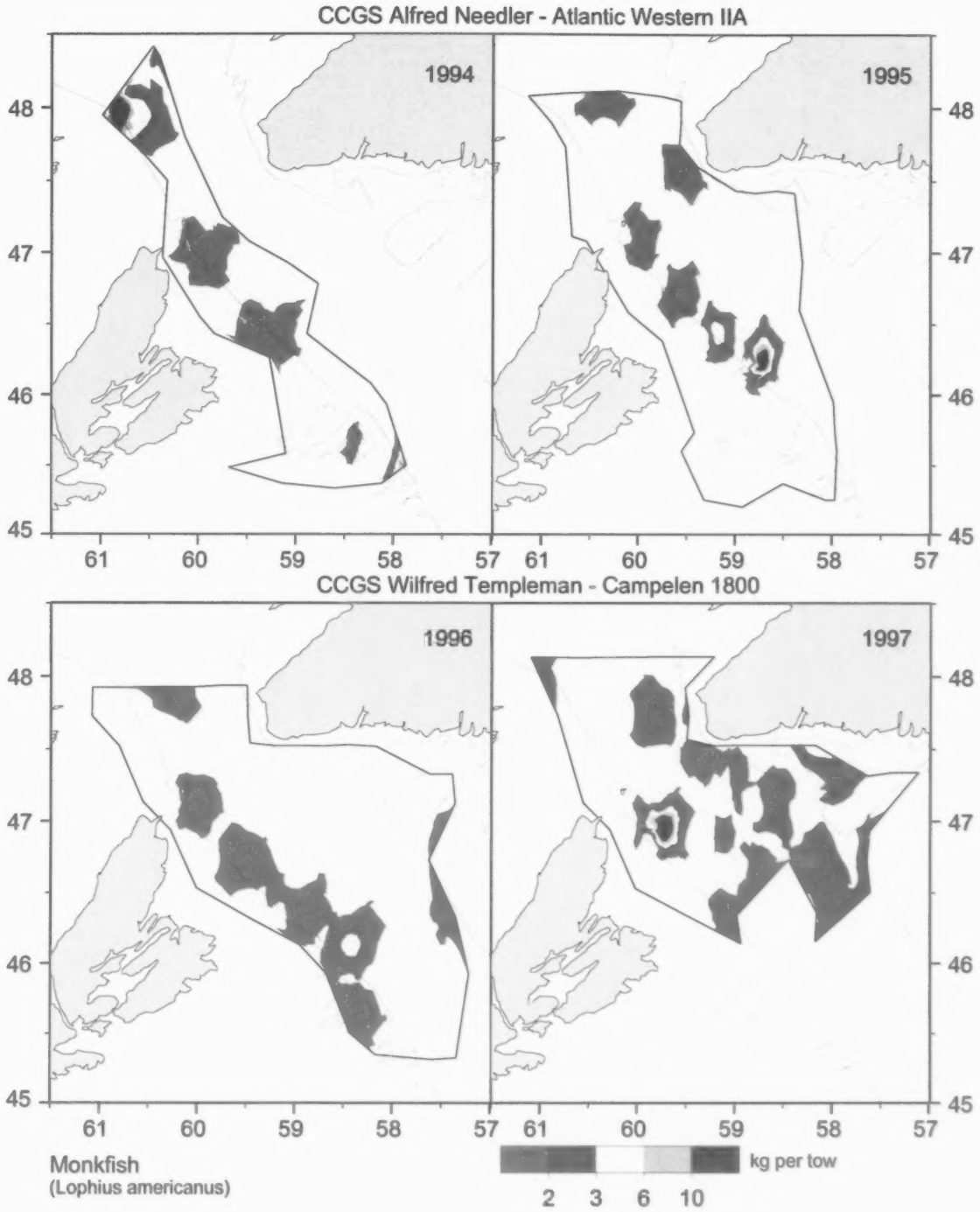

Figure 24a: Distribution of monkfish (*Lophius americanus*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

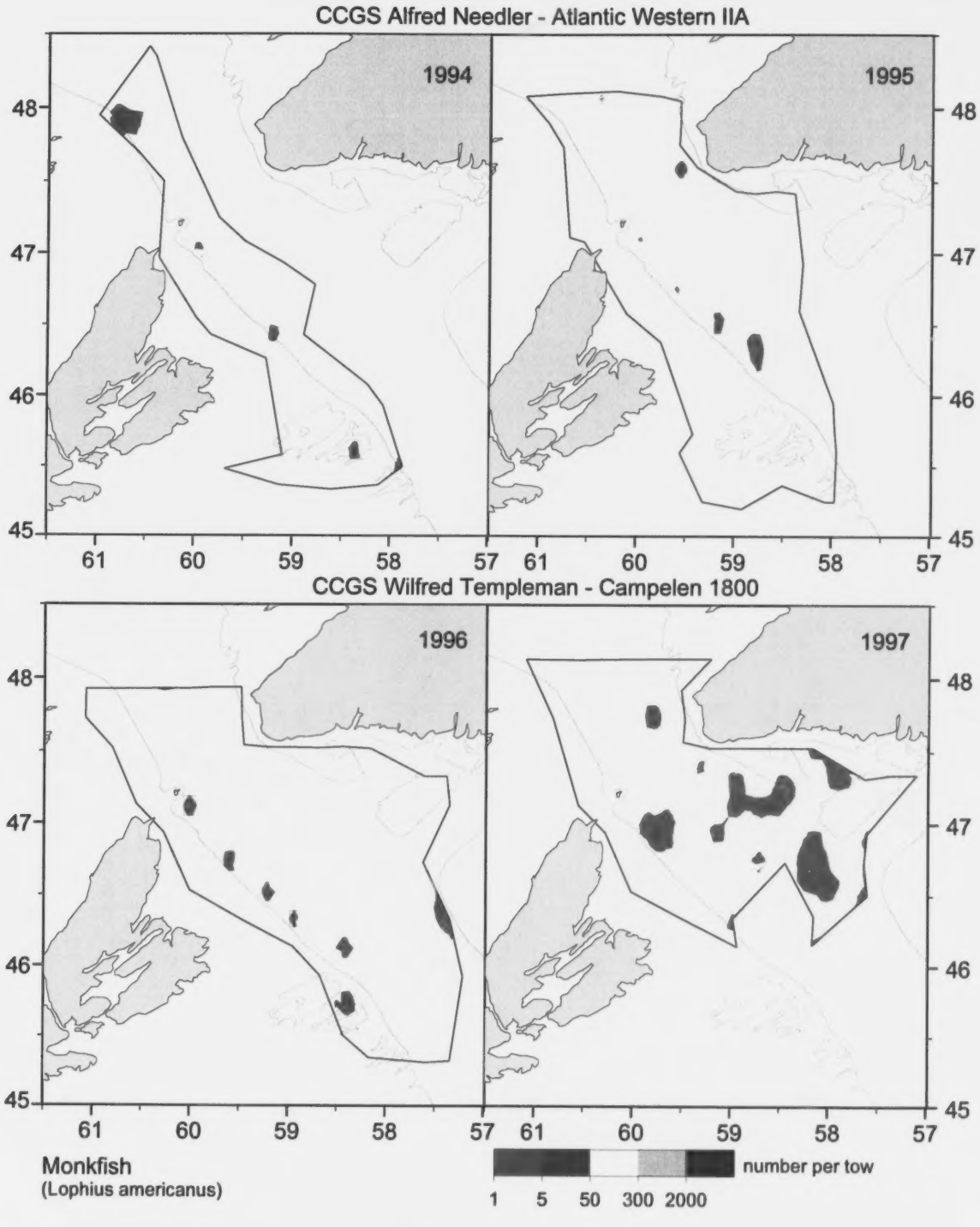

Figure 24b: Distribution of monkfish (*Lophius americanus*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

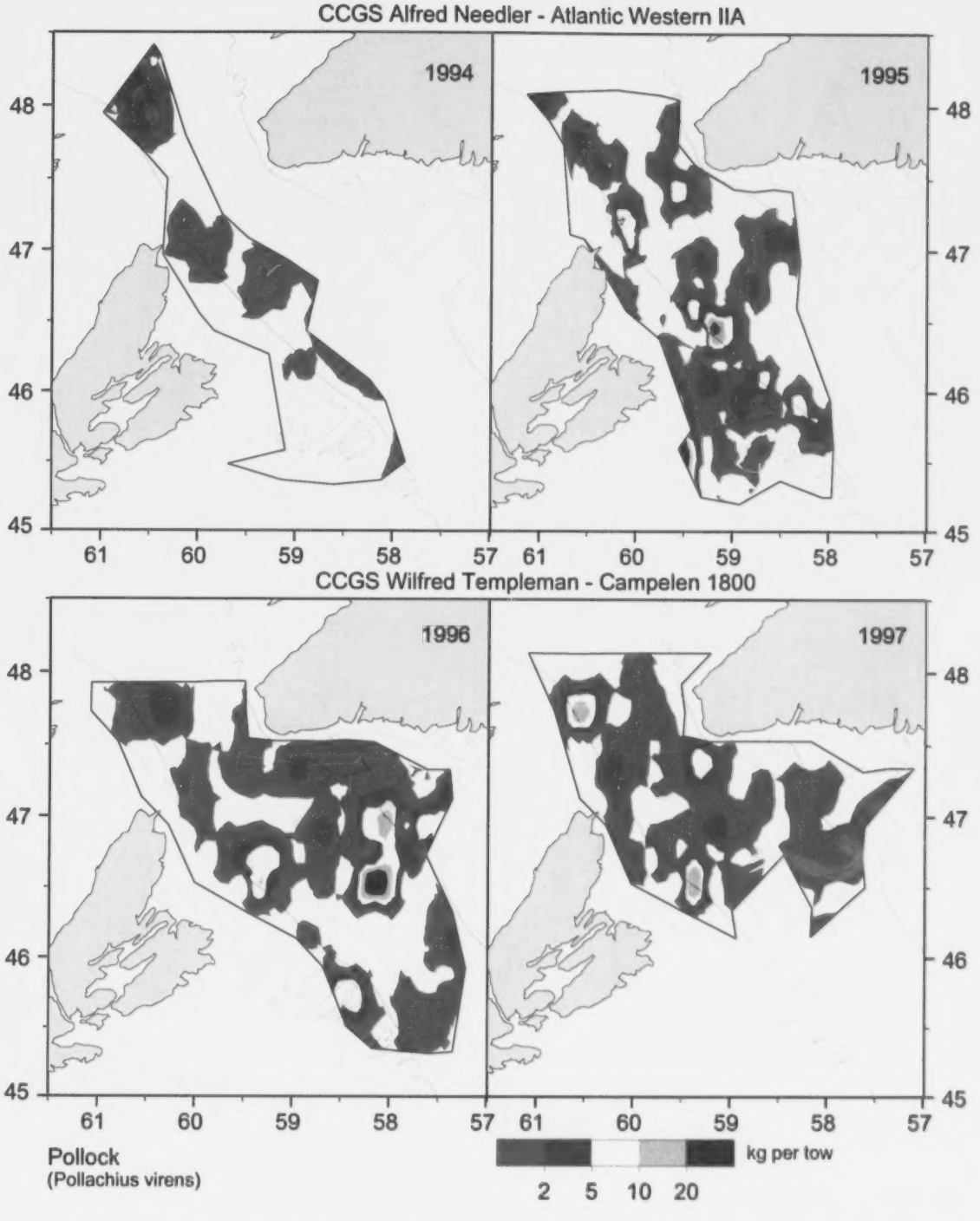

Figure 25a: Distribution of pollock (*Pollachius virens*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

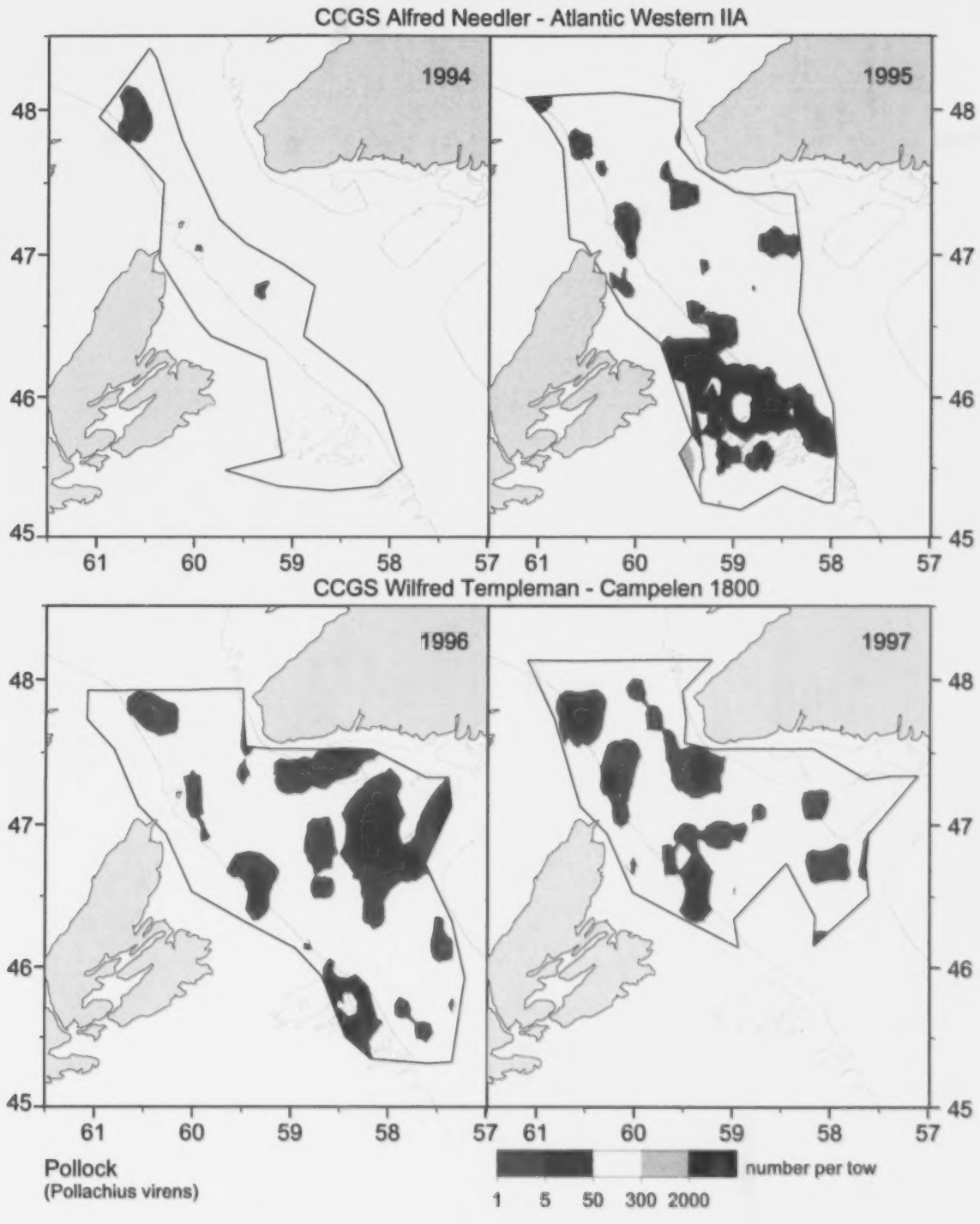

Figure 25b: Distribution of pollock (*Pollachius virens*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

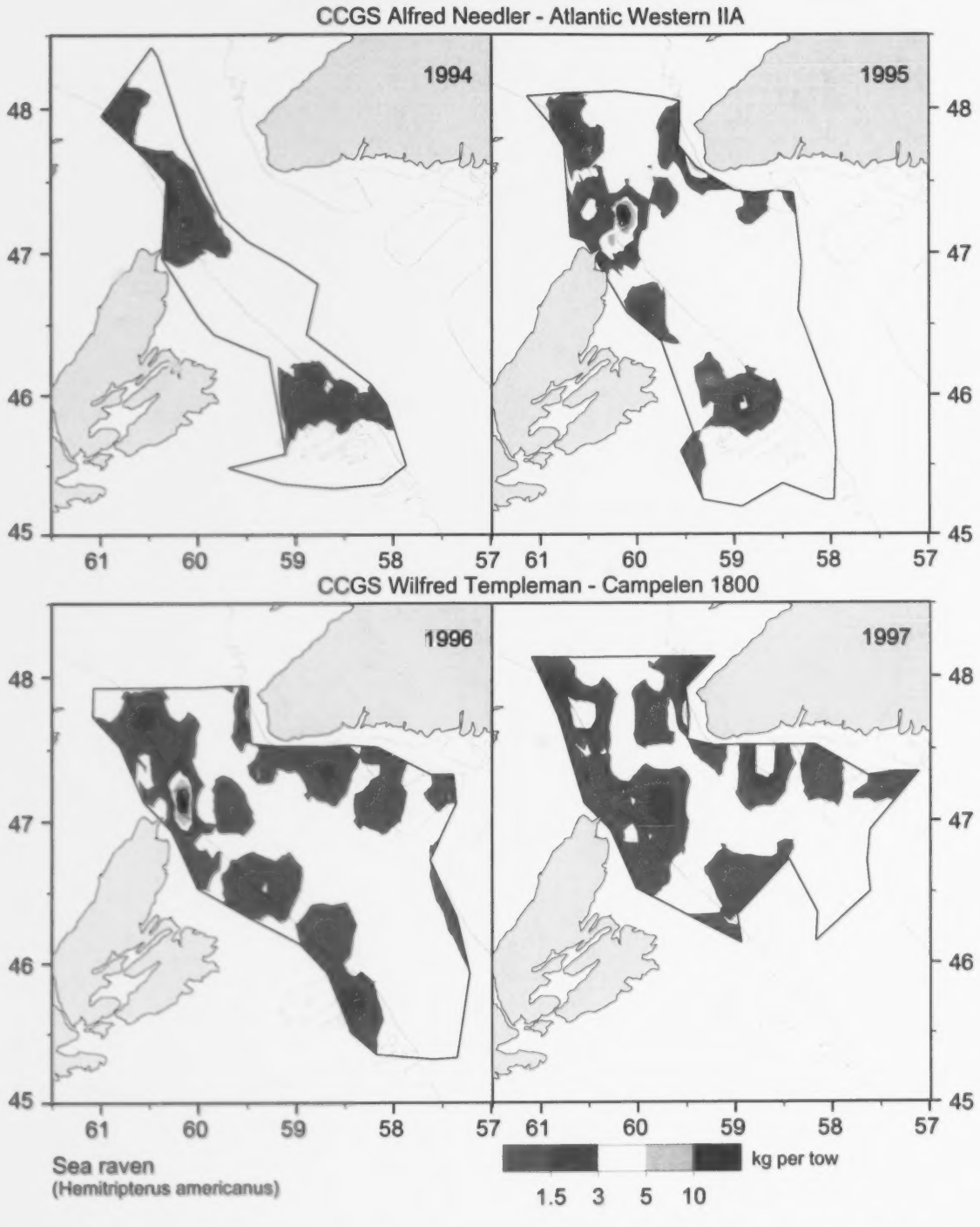

Figure 26a: Distribution of sea raven (*Hemitripterus americanus*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

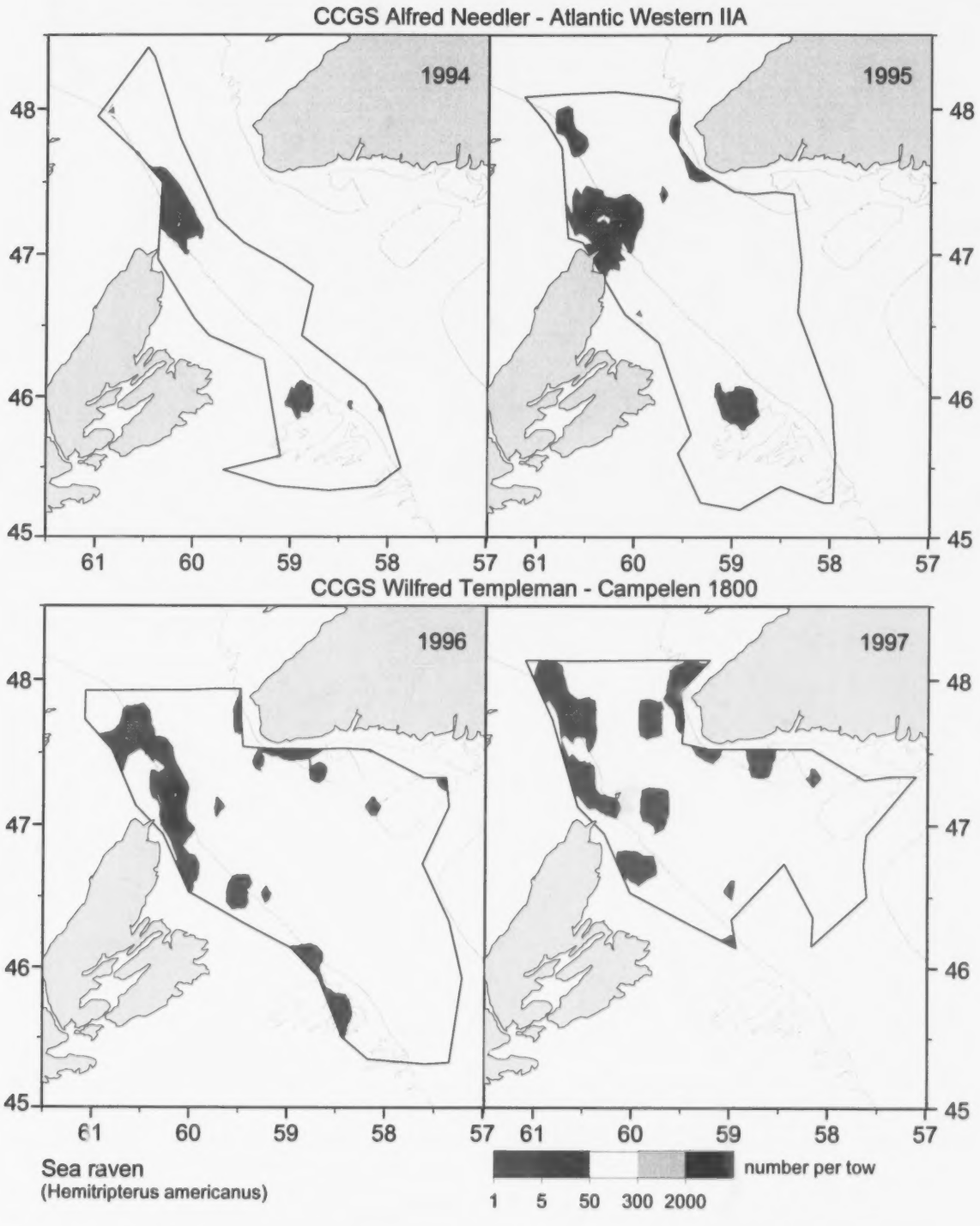

Figure 26b: Distribution of sea raven (*Hemitripterus americanus*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

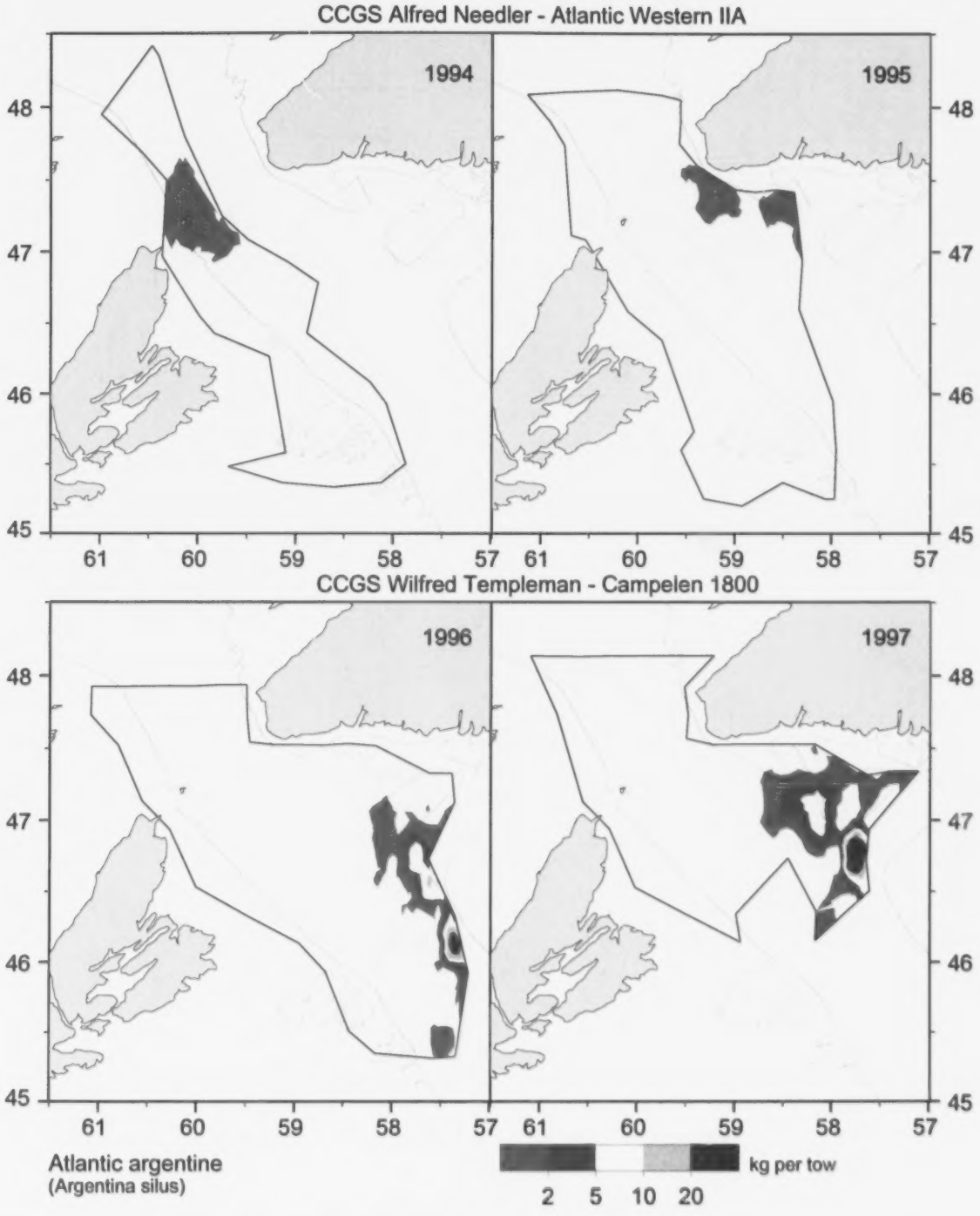

Figure 27a: Distribution of Atlantic argentine (*Argentina silus*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

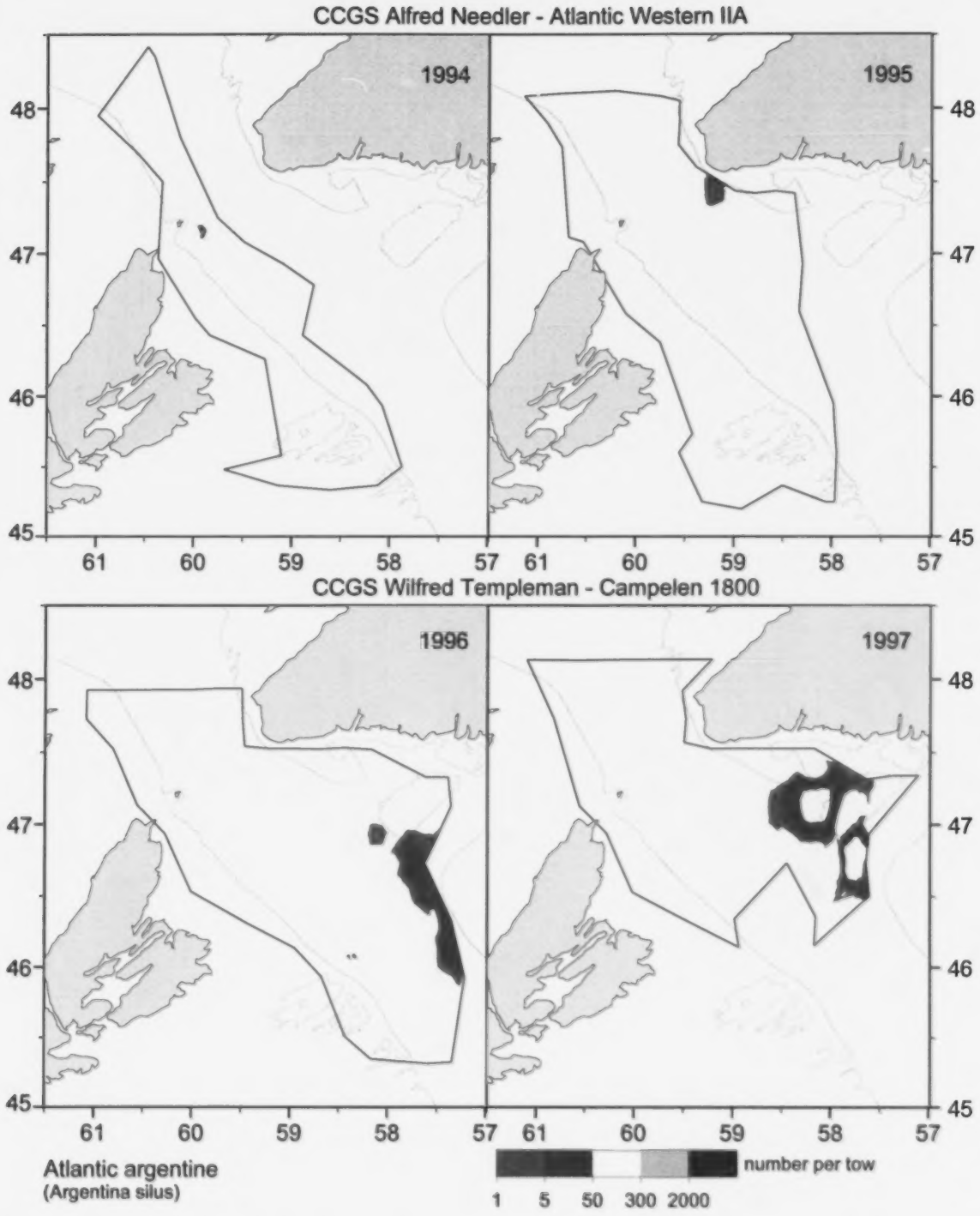

Figure 27b: Distribution of Atlantic argentine (*Argentina silus*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

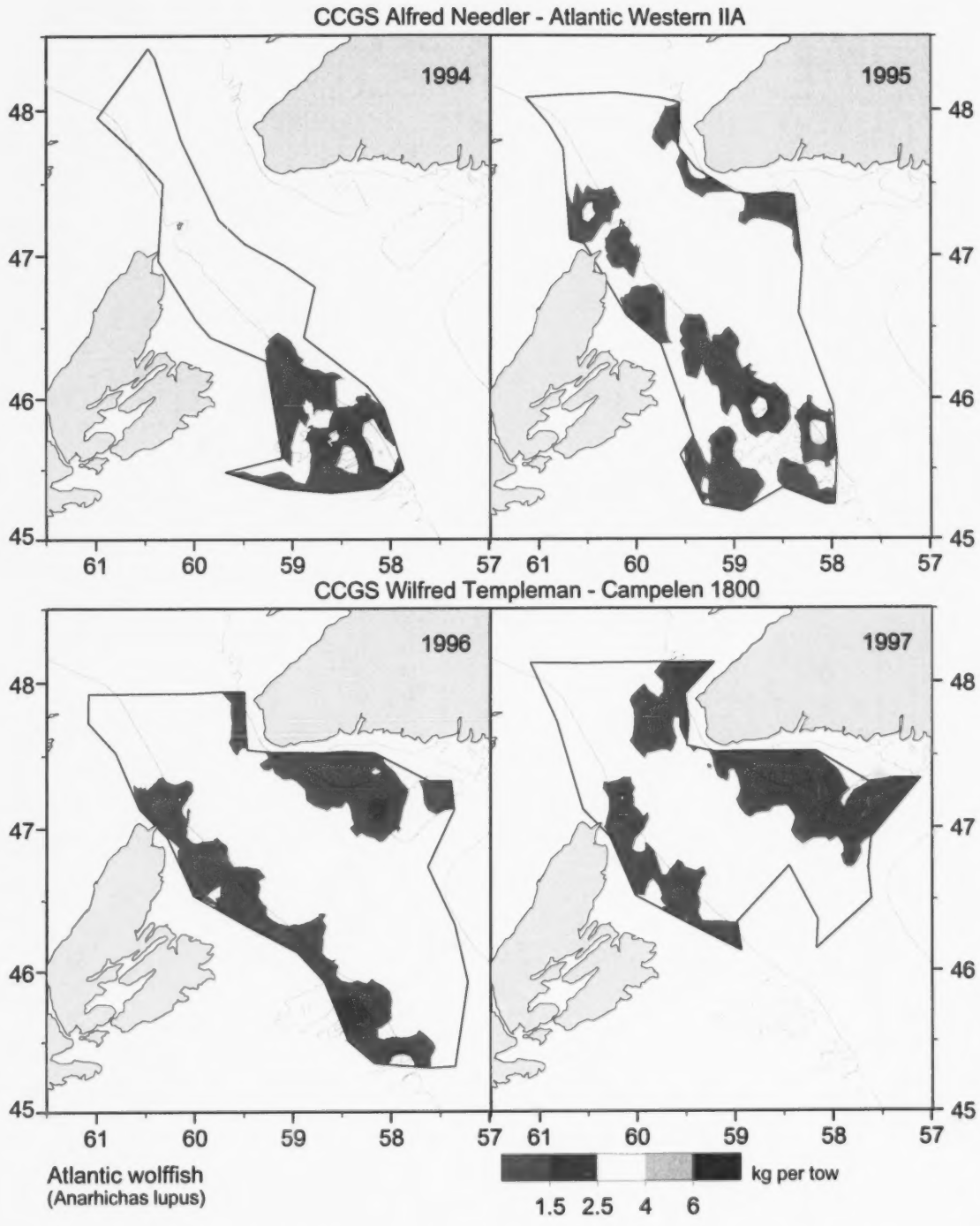

Figure 28a: Distribution of Atlantic wolffish (*Anarhichas lupus*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

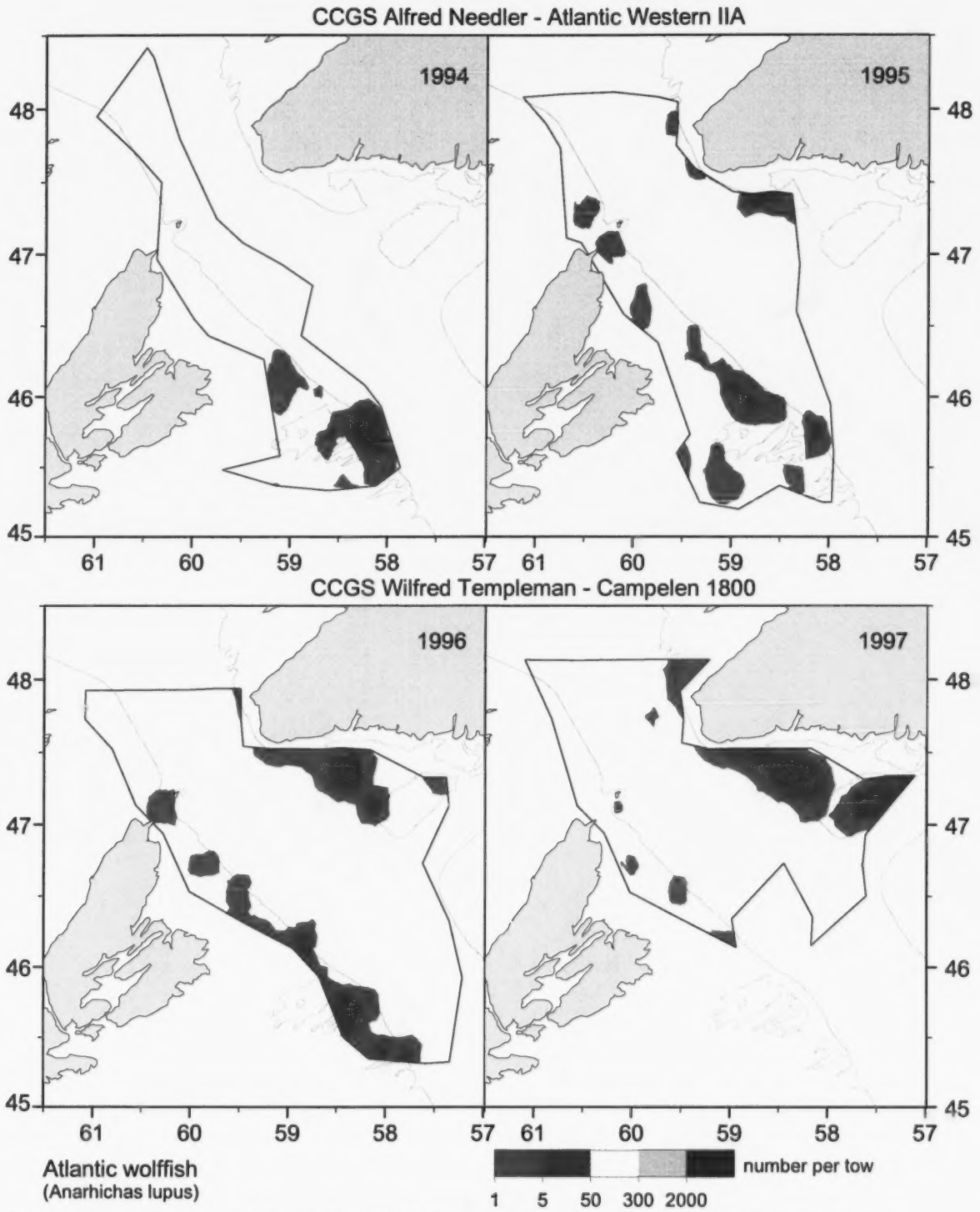

Figure 28b: Distribution of Atlantic wolffish (*Anarhichas lupus*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

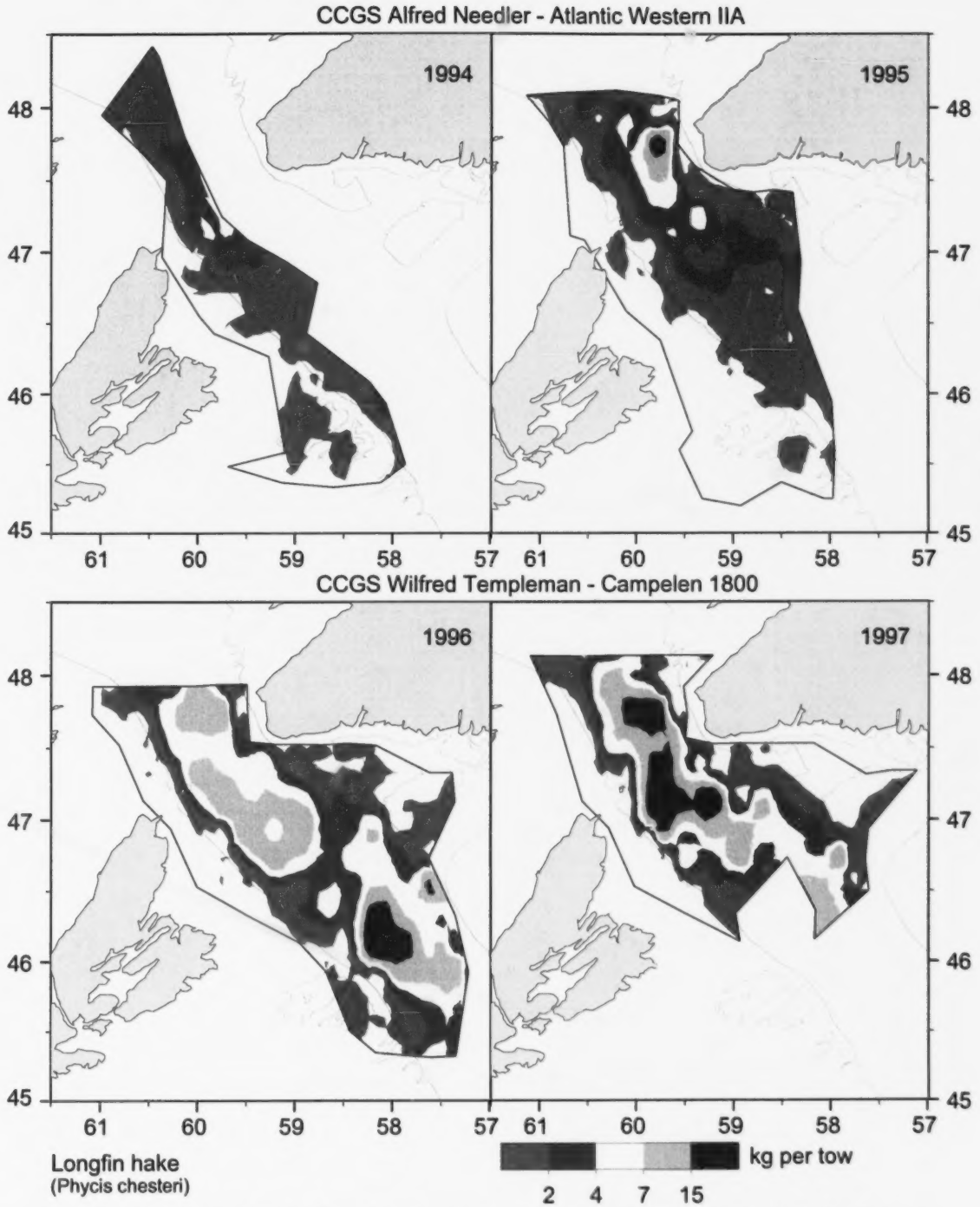

Figure 29a: Distribution of longfin hake (*Phycis chesteri*) catches (weight per tow) during January surveys conducted in Cabot Strait, 1994 –1997.

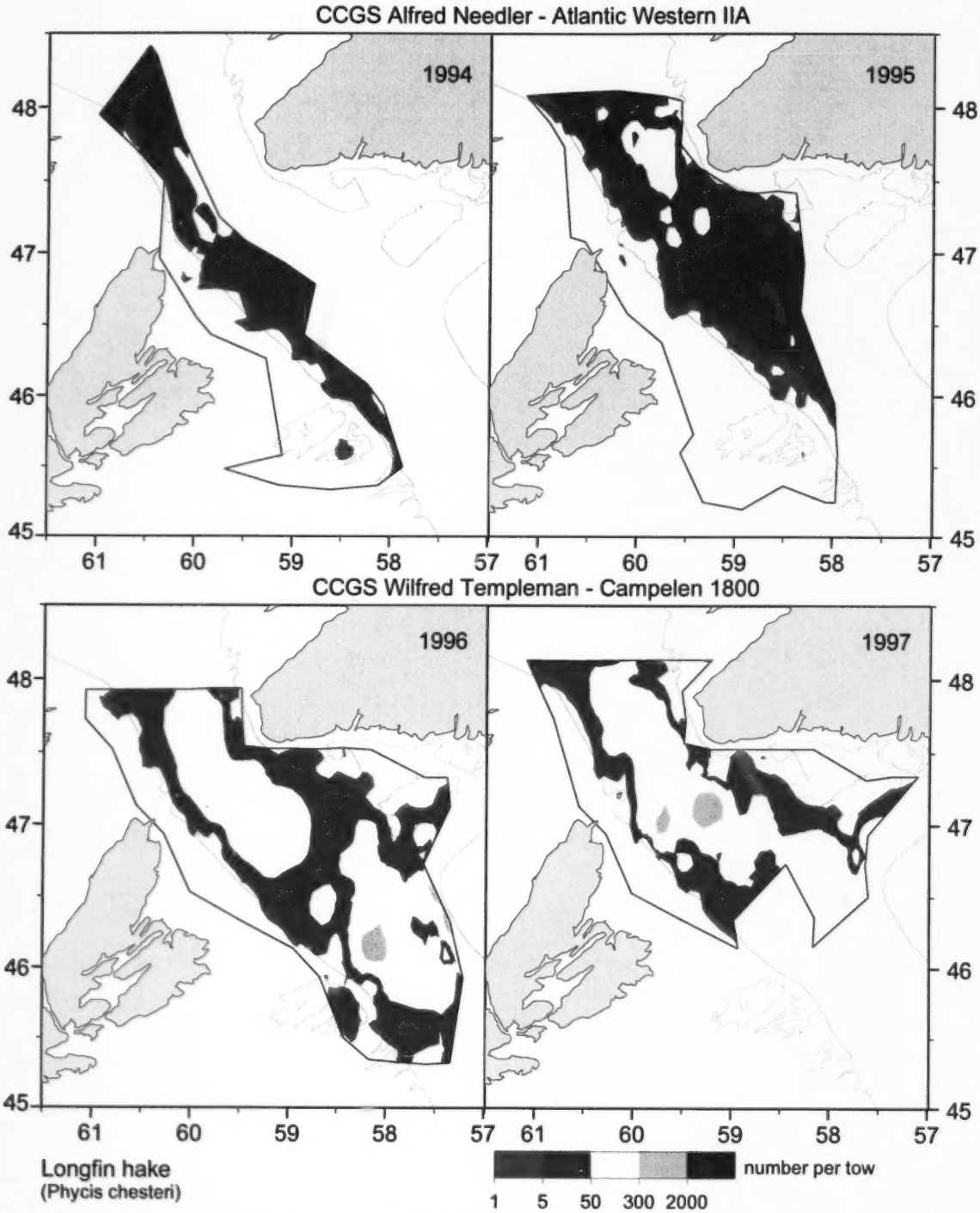

Figure 29b: Distribution of longfin hake (*Phycis chesteri*) catches (number per tow) during January surveys conducted in Cabot Strait, 1994 –1997.